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Modeling the Impacts of EU Bioenergy Demand on the Forest Sector of the Southeast U.S.

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Abstract: The wood-pellet trade between the U.S. (United States) and the EU (European Union) has increased substantially recently. This research analyzes the effects of EU biomass imports from the Southeast U.S. on Southeast U.S. timber prices, inventories and production and on EU imports of feedstock. The SRTS (sub-regional timber supply model) was used to simulate market responses to changes in woody biomass consumption in the U.S. and the EU between 2008 and 2038. Results indicate that the price of imported wood pellets in the EU is sensitive to future U.S. renewable energy policies, the developments of which are so far uncertain. The analysis indicates that with bioenergy demands, prices increase for U.S. softwood roundwood from 25% to 125% by 2038 depending largely on U.S. domestic policy. Demand increases led to supply responses and increased carbon storage in Southeastern U.S. over time.

Key words: Pellets, forest product markets, international wood trade.

1. Introduction

Energy supply and greenhouse gas emissions are global concerns. The EU has set an ambitious target of 20% of the energy consumption to come from renewable sources by 2020 [1]. So far, every country in Europe has included bioenergy in its energy and climate policies [2]. Meeting national targets for renewable energy will require intense mobilization of domestic sources as well as increased imports [3].

The European Commission proposal is to maintain the EU's position as a world leader in renewable energy [4] and the EU has declared it would use wood from sustainable sources only. The federal government of the U.S. also has a number of policies in place to promote the use of bioenergy (e.g., the Energy Policy Act of 2005 (Public Law 109-58)). Currently, the merits of these policies and the impacts on biodiversity, climate change and land use are under discussion.

Studies indicate that woody biomass resources within the EU will not suffice to satisfy the demand if the targets for renewable energy are to be met [3, 5]. Indeed, international bioenergy trade is already growing rapidly, especially for wood pellets. The main wood-pellet trade routes are from Canada and the United States to Europe, in particular to Sweden, the Netherlands and Belgium [6].

An increasing demand for bioenergy in the EU would have implications for forest sectors in other countries. Large-scale bioenergy imports to mitigate domestic biomass scarcity in the EU brings to the fore among other issues, the question of potential global biomass scarcity relative to the future required levels of climate neutral energy [7]. Studies such as EFORWOOD (sustainability impact assessment of the forestry-wood chain) and EFSOS (European Forest Sector Outlook Study) II [5] have assessed the

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implications within Europe of an increased demand for bioenergy. However, there is as of yet no comprehensive analysis of implications outside Europe (except Ref. [8]).

Fast growing conditions, abundant forest resources, and low-cost transatlantic freight make the Southeast U.S. an attractive source of biomass imports for the EU. At present, there is a lack of knowledge as to how forest inventories, forest-product markets and forest carbon in the Southeastern U.S. could be affected by the EU energy sector. Hence, sustainable forest management and wood market in the Southeastern U.S. may face constraints in terms of satisfying domestic and EU bioenergy demand.

Thus, the objectives of this study are to: (1) assess the impact of EU energy consumption on wood pellet imports between 2008 and 2038; (2) determine the influence of U.S. and EU bioenergy feedstock consumption on key market variables and carbon storage in the Southeastern U.S. To meet the objectives of this study, the authors use the SRTS [9].

2. Materials and Methods

2.1 Modeling and Assumptions

The SRTS model [9] was used to simulate market responses to changes in woody biomass consumption in the SE U.S. (Southeast U.S.) and EU-27 member states. SRTS is a partial equilibrium market simulation model. SRTS uses detailed forest resource information on stand ages, forest types and growth rates to model changes in inventory by product. These inventory changes, which can arise from land use conversion and forest type conversion—e.g., through tree plantation establishment—are used to shift product supply curves.

To project timber supply trends based on present conditions and the economic responses in timber markets, the SRTS model uses a U.S. Forest Service, FIA (forest inventory and analysis) [10] dataset of inventory, growth, removals and acreage by forest type, private ownership category, species group and age class for multi-county areas. FIA data are the key biological forest resource drivers for the inventory by forest management type, age class and species groups [9]. The SRTS model provides a simulation environment for examining sub-regional timber supply dynamics and their impact on supply in the aggregate market. The potential price consequences consider sub-regional inventory and harvest shifts and changes in market demand.

Studies indicate that supply and demand price responses are inelastic [11, 12]. In this study, the authors assumed -0.5 and 0.5 for the elasticity of demand and supply respectively with respect to real price changes and an elasticity of supply with respect to inventory of 1.0 for all products implying that supply shifts are proportionate to product inventory change. The SRTS model assumes constant elasticity functional forms. The demand scenarios determined the demand curve shift in each year [13]. Biomass demand is met by both logging residues and industrial roundwood. The roundwood portion of this woody biomass demand quantity competes with the demand for roundwood used in the traditional forest products sector.

There are three components of each demand scenario. The first component is the demand for roundwood used in the traditional wood using industries in the SE U.S. Since the focus of this research was bioenergy, an assumption was made that demand for traditional forest products would fully recover from the most recent recession by 2014 and remain constant thereafter (Fig. 1). The rate of demand

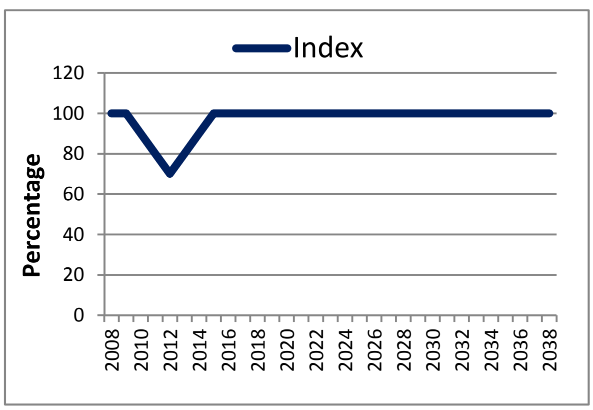

Fig. 1 Baseline domestic demand trend with a modeled recession and rebound.

change between these particular years will be equal to 33%. Recession and rebound will significantly influence the harvest level.

This recession is modeled as V-shaped with a sharp downward trend, a nadir at the depths of the housing market slump and then an equal and opposite upward trend that returns demand to pre-recession levels by the year 2014. While evidence is still lacking about actual (observed) harvest rates to the current year (2012), housing starts data from the U.S. Census Bureau (2012) indicate that the bottom was reached in 2009 but that recovery has not proceeded exactly in a V-shape but may be closer to a U-shaped recovery [14]. Stumpage prices for southern pine and mixed hardwood sawtimber and pulpwood have also failed to recover since the contraction in U.S. construction [15]. Nevertheless, a return to pre-recession long-term average demand levels, the authors contend, is a reasonable representation of long-run future market conditions.

Domestic (U.S.) bioenergy demand makes up the second component. Results from Ince et al. [16] were used for this component, which includes a high, a medium and a low domestic bioenergy demand scenario, projecting the demand for woody biomass into the coming decades. The United States is one of many countries where national energy policies have been enacted. Among the most important, the EISA (energy independence and security act), was introduced in 2007. This act and proposed legislation regarding national renewable energy goals for electric power can in the near future expand wood use dramatically for liquid fuel, electric power and thermal energy production [16].

Research by Ince et al. [16] used U.S. renewable energy projection from the 2010 U.S. Department of Energy Annual Energy Outlook, AEO (USDOE, 2010), which incorporates the impact of the U.S. Renewable Fuel Standard (under EISA). This study also incorporated the anticipated market impacts of a hypothetical national RES (renewable energy standard) for electric power.

The model used to evaluate the market effects of alternative scenarios was the USFPM (U.S. Forest Products Module), which was embedded in a global partial spatial equilibrium model of the global forest sector, the GFPM (Global Forest Products Model) [17]. The USFPM module provides a three-region, multi product of timber and wood residue markets.

Ince et al. [16] describe four scenarios that were used to project market impacts of alternative policies that affect U.S. wood energy demand. Scenarios differed from one another mainly in terms of assumptions about future expansion in U.S. wood energy consumption through 2030. Full description of all scenarios can be found in Ref. [16]. Generally, all scenarios include projected U.S. cellulosic biofuel output under the U.S RFS (renewable fuels standard policy) as projected by the 2010 AEO (annual energy outlook) [18]. The scenario labeled “HP” (C2) has a higher cellulosic biofuel demand projection from the AEO “HP” (High Oil Price) case, while the other three scenarios use the RFS biofuel projection from the AEO Reference Case. All scenarios include additional biomass energy consumption under hypothetical national RESs (renewable energy standards) requiring that either 10% (RES 10; Scenario A2) or 20% (RES 20; Scenario B2) of electric power be generated from non-hydro electric renewable energy sources by 2030. The last scenario, labeled “RES 20 + EFF”, includes a similar energy policy but allows half of the non-hydro renewable energy to be in the form of more efficient combined heat and power (EFF), therefore requiring somewhat less biomass input to attain the 20% renewable energy requirement [16].

The focus of our study is on the third component, i.e., EU-27 wood pellet imports from the SE US. Our EU estimates were based on Capaciolli et al. [19] and included three scenarios. Based on recent research, Eurostat and USITC databases [20, 21], it is concluded that wood pellets are the main bioenergy feedstock traded between North America and Europe. As total biomass consumption is predicted to increase in coming years, pellets are regarded as one of the important bioenergy commodities traded internationally that will contribute a significant share of total biomass consumption growth. To determine how much of total EU pellets imports are sourced in the U.S, it is necessary to distinguish the percentage of U.S. pellets among all pellets imported by EU-27 countries. Based on the Eurostat database, results show that U.S. contributes 30% to 56% of total imported wood pellets from third countries to EU-27. This discrepancy or range was caused because Eurostat provides two types of independent information about pellet import from third countries.

The authors therefore imputed this value at 40%, which while arbitrary, is simply a rounding to the nearest 10%, just slightly less than the midpoint. Scenarios are summarized in Table 1.

A critical variable to address in simulations is the moisture content of wood pellets. The most significant factor that relies on moisture is the amount of feedstock that is needed to produce one ton of pellets. Sikkema et al. [22] analyzed three conversion factors that can be used to determine pellets moisture. These authors examined three different types of wood pellets (bulk pellets for district heating in Sweden, bagged pellets for residential heating in Italy, and bulk pellets for power production in the Netherlands). To produce one ton of bulk pellets (8% moisture content) for district heating in Sweden, around 2.12 t of feedstock (average moisture content 55%) are required. To produce 1 t of bagged pellets (10% moisture content) for residential heating in Italy, around 1.78 t of feedstock (average moisture content 47%) are needed. And finally, to produce 1 t of bulk pellets for power production (6% moisture content) in the Netherlands, around 1.57 t of feedstock (average moisture content 36%) has to be used [22]. For all scenarios, the authors assumed a value of 1.78 to determine the amount of feedstock needed to produce 1 t of wood pellet (moisture 10%). Sensitivity analysis was performed using all conversion factors (1.57, 1.78, 2.12) to quantify the importance of pellet moisture content on natural resources demand and wood markets in the SE U.S.

The authors used SRTS, the various biomass harvesting and residual factors and the U.S. and EU renewable energy policy inputs to estimate the impacts of EU biomass demand on multiple variables. These include: SE U.S. timber inventory, supply and prices; carbon storage; and the amount of forest plantations in the region.

The authors focused on softwood pulpwood markets, which comprise the largest share of relevant harvest in the SE U.S. and an even greater share of wood used for wood pellets and chips exported to the EU. The different levels of EU demand depended on the four scenarios presented in Table 1.

2.2 Geographical Scope

The market and resource implications of increased EU imports of wood for energy were analyzed assuming demand was met by (1) the entire SE U.S., (2) only the coastal plain component which is closer to Atlantic ports. In this paper, only results for the entire SE U.S. are presented. Detailed results for the coastal plain, quite similar, can be found in Chudy [23].

This study defines the SE U.S. as the region comprised of the states of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia (Fig. 2).

Table 1 Combined scenarios of EU-27 pellet imports from the U.S. and wood fuel feedstock demand in Southeast U.S..

Scenario name	Wood fuel feedstock demand in the Southeast U.S.	Percent of U.S. pellets delivery to EU (%)
Baseline	no use of biomass for energy	0
A2 = Low	RFS + RES10	40
B2 = Medium	average of RFS + RES 20 and RFS + RES20 + EFF	40
C2 = High	RFS + RES20 + HP	40

The SE U.S. states are the main focus of the SRTS model and its relationship to the regions as defined in the FIA database. The SE U.S. has a large amount of forest resources available in this area and the potential for export of woody biomass to EU.

2.3 Species Supply Composition

One of the key assumptions is that 80% of wood for pellets will come from softwood. Harvest levels have historically been low in hardwood forest types across the South [9]. This is mainly due to lower growth rates, restricted availability (steep slopes or wet soils, small tracts) and because landowners of these management types traditionally have had other objectives for owning their land in addition to or in place of profits from timber production.

The 80% softwood fiber content that the authors assume is slightly at odds with recent historical experience, but the assumption withstands scrutiny for at least two reasons. Recent data [10] show that softwoods comprised roughly 65% of total harvest volumes in the SE U.S. and 77% to total harvest volumes in the coastal plain. However, recent growth rate information indicates that the plantation-based softwood species that manufacturers currently utilize will increase in productivity faster than the natural stand-based hardwood species that have made it into wood pellet furnish in recent years. Additionally, the analysis and assumptions accordingly focused on softwood timber harvests, based on the predicted higher demand of fast growing species devoted for biomass. Wood pellet plants use higher proportions of softwoods than hardwoods in pellet manufacture; some recently established plants using 100% softwood. This assumption takes account of slight changes in the pellet supply chain but also recognizes existing wood resource availability the SE U.S. One should bear in mind that hardwoods are composed of many different species (as compared to one-species softwood plantations), which can influence woody biomass quality.

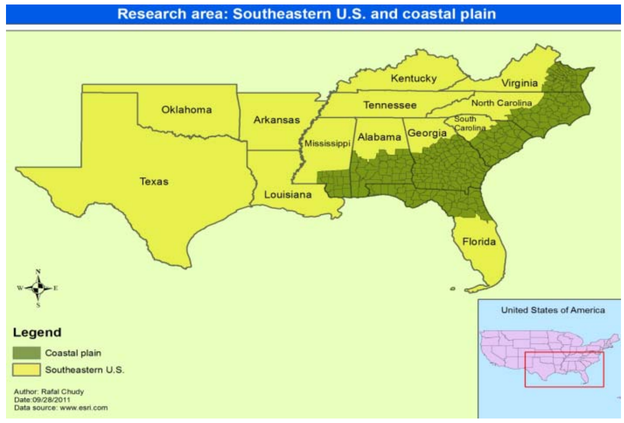

Fig. 2 Research area: the Southeastern U.S. and its coastal plain.

2.4 Harvesting Residue Rate and Recovery Rate

As far as the supply side is concerned, the recovery rate and the harvesting residue rate are the most important factors that determine how much biomass can be extracted from a harvest site. The harvesting residue rate quantifies the proportion of total wood biomass that remains after timber harvesting operations, in other words, which part of total stand yield will be left on the ground after harvest. On the other hand, the recovery rate also indicates how much of that residual biomass left on the ground can be extracted after timber harvest. In the literature there is wide variation in this rate. The biggest discrepancy in the research studies is the relation between theoretical and practical rates of biomass recovery rate for specific regions.

Some authors have not recognized an operational reality that the extraction of 90%-100% of biomass, while possible on some sites, is not likely to be attainable across whole regions. This derives from a large number of factors, including transportation costs, unfavorable site conditions, unfavorable tree species compositions, forest practice guideline constraints, legal limits related to wetland protection, limits on harvestability connected to threatened and endangered species and habitat protections, laws limiting rates of stream sedimentation, owner preferences, and the high cost of harvesting small residues. The technology to harvest a high amount of residue exists, but costs and environmental conditions play a significant role. For example, marshes or mountainous areas significantly decrease biomass removals. In the SE U.S. there are the huge variations in forest conditions.

To accommodate the practical limits on recovery and harvesting residue rates due to the above factors, two alternative values of the harvesting residue rate were used. The applicable value for a particular site was determined based on forest types (coniferous and broadleaves), as identified by the FIA data. According to FIA, the harvesting residue rate for coniferous stands is approximately 20%, while for hardwood stands it amounts to about 40% of wood removals. The difference between the values for coniferous and hardwoods can be understood by the circumstances that after harvest operation in hardwood stands, more branches, limbs and other woody parts will remain on the ground, compared to coniferous trees, which have fewer branches and straighter stems. The FIA define and reports biomass as the aboveground dry weight of wood in the bole and limbs of live trees ≥ 1 inch in diameter at breast height (d. b. h). According to FIA, tree foliage, seedlings and understory vegetation are excluded from above definition [24].

The assumption about recovery rate is derived from a study by Jurevics [25]. The main objective of that study was to estimate optimistic and conservative ranges of available logging residues. In this study the value of 60% is considered as the most suitable in terms of residue availability and policy-based goals based on Ref. [25]. Furthermore, removing residues can reduce the costs of site preparation and the risk of wildfire. Ince et al. [16] use the same recovery rate value (60%), which was the key to modeling U.S. wood fuel feedstock consumption in this study. Finally, empirical evidence suggests that a 60% recovery rate is realistic for harvesting operations using conventional equipment [26]. A study assessing the potential for biomass energy development in South Carolina reflects the plausibility of this rate of recovery [27]. More studies are needed in the future to determine the recovery rate and its influence on sustainable delivery of biomass to wood industry.

3. Results

In the baseline run of timber supply in the South, there was little change in the price of softwood pulpwood, as represented by the price index, which reflects net timber supply impacts in the market model (Fig. 3). After the initial dip in the price index during the V-shaped recession, there were only small differences in the softwood pulpwood price index between 2008 and 2038.

Under the three bioenergy demand levels, timber prices increased significantly at various rates, ranging from 25% to 125% by year 2038 (Fig. 3). High demand scenarios produced the largest impact on timber markets and prices. The low and medium scenarios were similar in terms of effect on market outcomes, increasing prices from 25% to 50%. There were modest impacts in all three scenarios up to 2020, with an approximate 25% increase in timber prices, but the highest demand levels increase the market effects dramatically after that.

Substantially increased timber prices in the SE U.S. due to increased U.S. and EU energy policy demand would also probably affect that policy. EU's wood pellet importers are sensitive to future U.S. renewable energy policies and prices, the developments of which are so far uncertain. U.S. domestic wood fuel feedstock utilization has the main impact on wood market in the SE U.S and its coastal plain.

Under all scenarios and for both the SE U.S. as a whole and for the part of the SE U.S. with the most active wood pellet market, the coastal plain, carbon storage increases because of a positive planting response among private forest owners to higher timber prices and due to a conversion of marginal agriculture land to forest (Figs. 4 and 5).

High wood demand causes a price signal for private forest owners to plant trees. Moreover, newly established plantations compensate carbon loss from

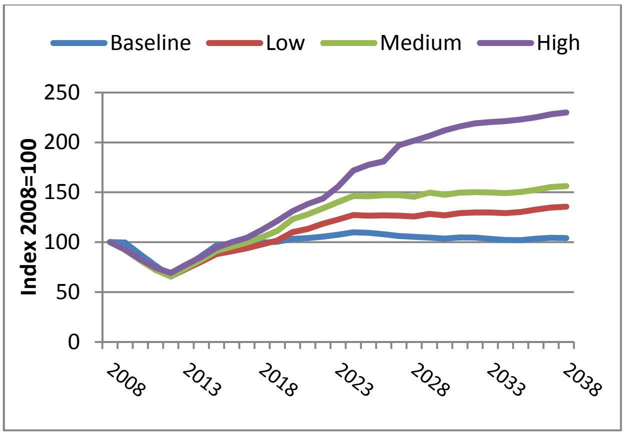

Fig. 3 Softwood pulpwood price in the Southeastern U.S. under different demand scenarios.

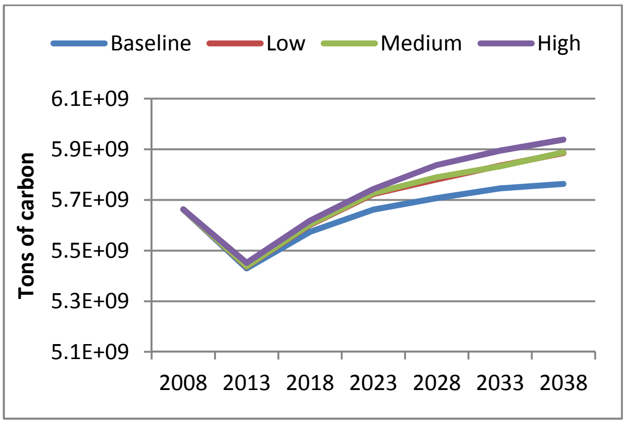

Fig. 4 Carbon storage in the Southeastern U.S. under different demand scenarios.

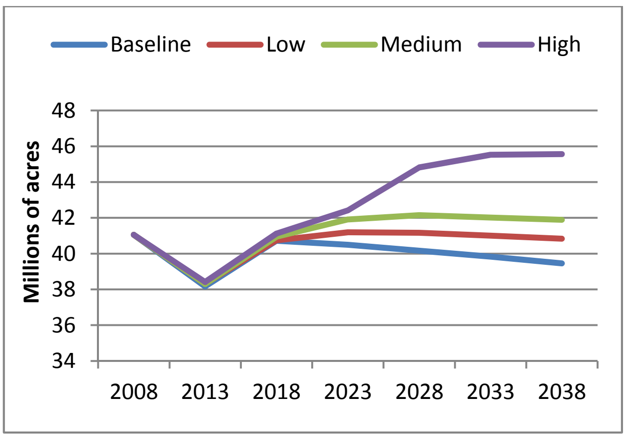

Fig. 5 Plantation acreage in the Southeastern U.S. under different demand scenarios.

higher harvest levels. A positive planting response may be advantageous, both to the regional economy and the environment.

All of the market impacts discussed above assume full utilization of available residues, with a minor exception for hardwood residues in the low scenario. This level of utilization may adversely affect site productivity, biodiversity and sustainable forest management. Separate research would be needed to address this issue.

4. Conclusions

This paper assesses the projected influence of EU wood biomass consumption and U.S. renewable energy policies on the forest market and carbon storage in the SE U.S. Both U.S. and EU policies are important with respect to sustainable use of natural resources, efforts to mitigating greenhouse gas accumulation, international timber product markets and trade. In this study, the authors find that the prices paid by EU importers for U.S. domestically produced wood pellets are sensitive to U.S. domestic renewable energy policies, whose future development is yet uncertain.

There is considerable evidence that biomass trade, especially in the pellet sector, will increase. Our results indicate that, at low EU pellet import demand levels, the impacts of woody biomass from forests will not have extreme effects on timber markets, and may even encourage carbon storage and planting of more forests. But if EU pellet import demand were coupled with an aggressive U.S renewable energy policy, timber prices would increase substantially, which is not likely to be sustainable economically. In this case, adverse impacts on natural resources could emerge. Furthermore, the existing forest products industry sector in the South would be adversely affected by much higher prices, and might therefore oppose such renewable energy policies.

Bioenergy policy seems to be the most influential factor on wood utilization and trade. Because both U.S. and EU policies regarding renewable energy are in states of flux, it is essential that future research into their forest sector impacts incorporate the latest policy developments. Such research could also be enhanced with studies of the price elasticity of biomass demand in the EU. Likewise, more specific data on wood flows to and from different countries, connected with clear specification of product codes and relatively quick actualization of databases, would be an important step towards analytical improvements. Linking EU demand models with U.S. supply models explicitly incorporates inventory dynamics and domestic competition effects on biomass price.

A better functioning bioenergy market is a matter of both time and policy reform. Increasing biomass demand will drive progressive infrastructure development while policy reforms can accelerate this process. Nevertheless, this research provides reasonable first-order estimates of the possible impacts of bioenergy demands on timber markets in the SE U.S., which can foster more discussion about the merits of the policies that the U.S. and EU adopt and revise.

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