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Introduction

The growing reliance in the United States and many other industrial countries on foreign petroleum has generated increasing concerns. Since the 1970s, many administrations have called for energy independence, with a particular focus on petroleum. Although energy sources are many, the transport sector is driven largely by petroleum. Despite calls for reduced oil imports, the United States increasingly depends on foreign supply sources. General concerns about the security of petroleum supply are compounded by added concerns about the emissions of greenhouse gases (GHGs) from fossil energy, including petroleum. While the United States did not ratify the Kyoto Protocol, efforts are increasing to find alternatives to petroleum as the dominant transport fuel. The major impediment to alternative fuels is generally their higher costs as well as the existing infrastructure, which has been developed to facilitate a petroleum-driven economy.

Europe is moving to supplement fossil fuel use with renewables, including biomass and particularly wood, in energy and heating functions in part through direct and indirect subsidies (e.g., Sjolie et al. forthcoming). Additionally, biodiesel is increasingly used as a substitute for fossil fuels. In Brazil, sugar-based ethanol has been a successful supplement to gasoline.

Here we examine the potential of cellulosic biofuels, particularly wood, as a feedstock to produce liquid transport fuels as a substitute for petroleum-based gasoline. The focus is primarily on the U.S. experience in using and developing biofuels and the possibility of wood as an alternative feedstock for liquid fuel.

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[1] Resources for the Future, Washington, DC and Ohio State University, respectively. This paper is drawn from a presentation to the Forest Sector Modeling Conference, University of Washington, November 17–20, 2008.

Biofuels in the United States

CORN-BASED ETHANOL

Subsidizing corn-based ethanol in the United States began with the Energy Policy Act of 1978. The Clean Air Act of 1990, driven by environmental concerns about adverse pollution emissions from petroleum products, required gasoline to have a minimum oxygen percentage, favoring high oxygen additives like ethanol (McCarl and Plieninger 2009). Corn, traditionally used as feed for animals and humans, can be broken down into sugars that are fermented to produce alcohol and ethanol. In recent years, growing concerns about achieving energy independence and reducing net GHG emissions has led to mandates and generous subsidies for corn ethanol, which has become the prime liquid biofuel in the United States.

Some analysts (Runge and Senauer 2007) believe that grain ethanol is not a feasible major long-term energy source because it creates financial stresses in food markets. In recent years, the demand for corn for biofuels has triggered a strong upward surge in demand for corn—up to 20 percent of the U.S. corn crop has been used for biofuel feedstocks. The result has precipitated rising worldwide corn prices and a decline in U.S. corn exports. Further concerns have been raised that a global corn biofuel approach could be self-defeating because it would require land-use conversions that emit GHGs, thereby offsetting much of the positive effect of any reduced consumption of petroleum (Searchinger et al. 2008). The problem of GHG emissions from disturbed lands, however, could be less severe for other biological feedstocks, such as trees and grasses (Sedjo 2008). These complexities are reflected in the evolving U.S. corn ethanol strategy, as evidenced by the Energy Independence and Security Act of 2007, which requires that future ethanol production involve in a major way other ethanol feedstocks, including cellulosic feedstocks.

WOOD ENERGY POSSIBILITIES: ORDINARY COMBUSTION

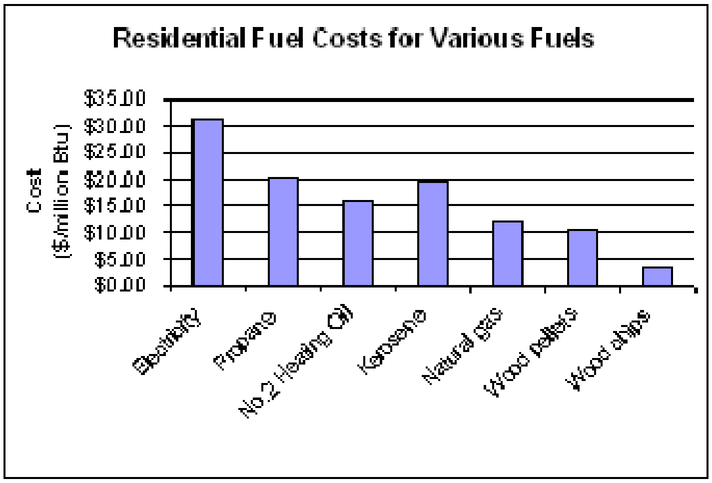
The possibilities for using wood energy are many. Ordinary combustion has been used for millennia and is still common in some situations. In recent years, a substantial market for wood pellets has developed for home heating, especially in North America, and as a supplement to both heating and power operations, particularly in Europe. It is estimated that producing one ton of wood pellets requires roughly three to four cubic meters of raw wood. Wood pellet use increased dramatically in recent years, from three million tons in 2000 to about nine million tons in 2007 (Wild 2008).

Wood pellets can be competitive with other energy sources for residential heating, as shown in Figure 1. Although cost estimates of these fuels vary, a representative average cost per million Btu of five fuels shows wood pellets can be competitive selling at $150 per ton and wood chips selling at a minimum of $30 per green ton (Bergman and Zerbe 2008).

Wood energy is not, however, without its problems. Even raw wood for direct combustion is, in most cases, more expensive than coal (Sedjo 1997). The costs for pellets, as noted in Figure 1, may be competitive with many nonwood energy sources. An advantage of any wood energy source is that, within the context of GHG accounting, wood does not generate net carbon emissions given the assumption of a closed biological cycle.

Wood energy is becoming increasingly popular in Europe because it is often subsidized directly or indirectly and users are not required to pay carbon emissions taxes (see, Sjolie et al. forthcoming)

Figure 1: Various Fuel Costs



Source: Bergman and Zerbe 2008.

Liquid Biofuels

Biofuels have generated the most interest as a transport fuel. Ethanol is currently produced from several biological feedstocks. Corn ethanol, blended with gasoline for transport fuel, is commonplace in the United States. Similarly, sugar ethanol is even more commonplace in Brazil and biodiesel is produced from Asian palm oil for European markets. Although not yet commercially viable, cellulosic ethanol production is on the horizon. Both cellulosic ethanol and synthetic petroleum could be produced directly though various processes, including gasification or by repurposing pulp mills for ethanol or biocrude production (Larson et al. 2003). Some of the issues and new U.S. legislation related to cellulosic ethanol are discussed in the following sections.

For liquid biofuel production, the processing costs of using a cellulosic feedstock are generally higher than the processing costs of using other biological feedstocks. Both the capital costs and costs associated wood processing are generally higher for cellulosic feedstocks because of the durability of cellulose and the high cost of enzymes needed to facilitate biofuel production. It is generally expected, however, that costs for wood or grass feedstock will be lower than alternative grain feedstocks, thereby providing a source of cost advantage. Also, technologies under development give promise of reducing cellulosic processing costs substantially (by, for example, lowering the cost of enzymes).[2]

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[2] For example, a new approach for genetically modifying plants to make biofuels that leaves the lignin in place but makes the cellular walls vulnerable to chemicals used in common laundry detergents could dramatically reduce processing costs (Mandel 2008).

Oil Alternatives: Costs and Emissions

For wood biofuels to become financially feasible at large scales, their costs must decrease or the costs of alternatives, including petroleum, must increase. Recent large fluctuations in the petroleum market demonstrate how relative prices can change the competitive position of various fuels. This can also be accomplished through policy (for example, government-imposed taxes or subsidies) or through mandated use levels. These approaches have been used for corn ethanol in the United States and are being introduced for cellulosic ethanol (Energy Act 2007).

Greenhouse Gases

A major rationale for moving to nonfossil fuel sources of liquid energy is related to the GHG emissions associated with fossil fuels. GHGs are emitted not only when those fuels are burned but also when they are produced. Table 1 provides estimates of net GHG reductions from substituting various biological feedstocks for petroleum. Note the poor relative performance of grains in reducing GHGs compared to the grass and wood feedstocks.

Table 1. GHG Emissions by Commodity: Life Cycle

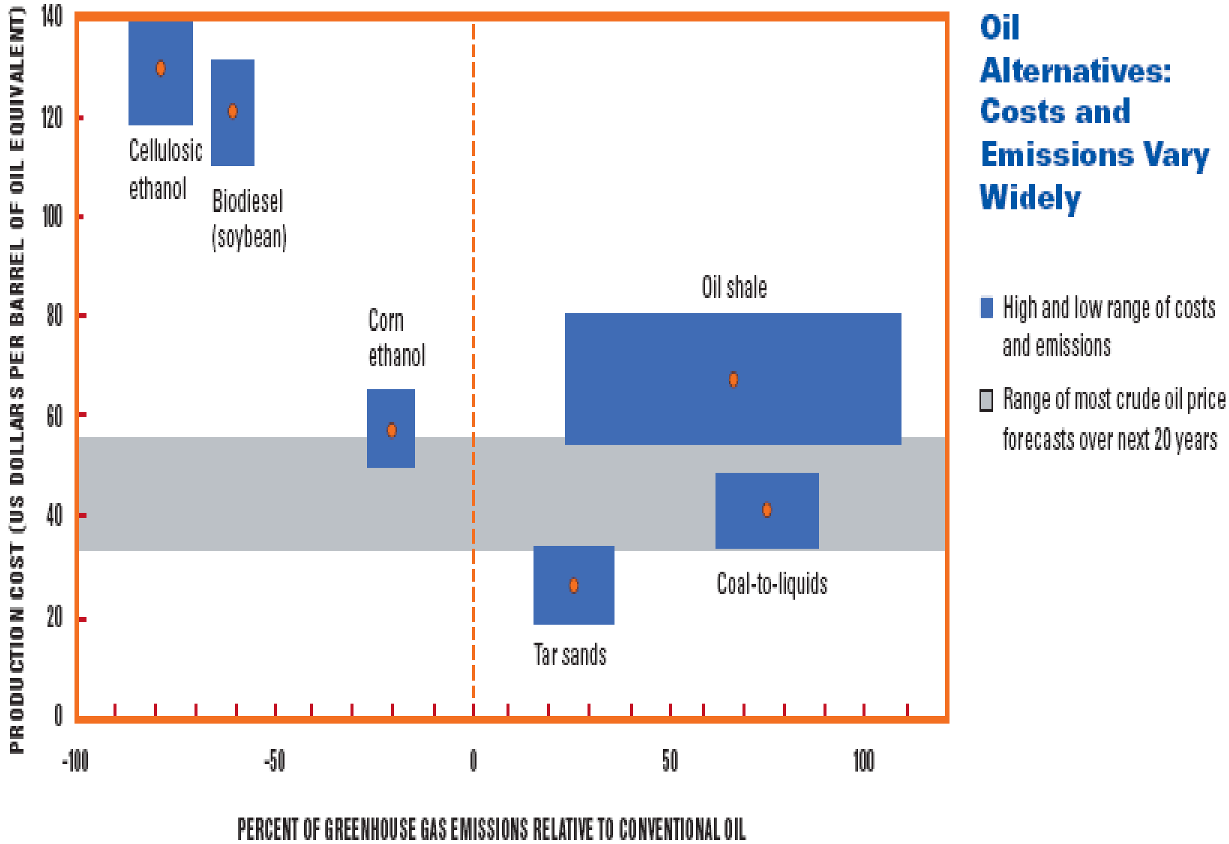
Cropping System	Net Reduction of GHG Emissions (%)
Corn and soybeans	40
Reed canary grass	85
Switchgrass	115
Hybrid poplar	115

Source: Colorado State University 2007.

Figure 2 shows estimated costs and GHG emissions of various technologies in 2006. Note that cellulosic biofuels have high costs compared to fossil fuel alternatives. For example, when oil is in the $35 to $55 per-barrel range, cellulosic ethanol cannot compete under current technology and costs without some form of policy assistance. With oil prices at $140 per barrel, however, all of the alternatives, including cellulose, are cost-competitive with petroleum. And if sugar and palm oil were included, their production costs would probably be below those of cellulosic ethanol and soybean biodiesel.

Estimates of total GHG releases of various biological and nonbiological alternatives compared to those of conventional oil on the horizontal axis are also illustrated in Figure 2; the comparative financial costs are on the vertical axis. Cellulosic biofuels have the lowest GHG emissions among the alternatives. Converting nonliquid fossil fuel sources (for example, tar sands, oil shale, and coal) to liquid fuels, by contrast, results in substantial increases in GHG emissions over conventional oil (at zero on the horizontal axis) because the conversion processes generate higher emissions. Biofuels, however, have net GHG emissions reductions over the conventional oil approach: although the conversion process generates emissions, burning the fuel itself is assumed to generate no new net emissions because the releases are offset by the biological regrowth of the feedstock.

Figure 2: Costs and GHG Emissions of Various Liquid Fuel Feedstocks



Source: Newell 2006.

Policy Assistance to Biofuels

Without policy assistance, most biofuels are not financially competitive with fossil fuels in most situations. Policy actions are, however, promoting biofuel development and use. Wood pellets are financially feasible in much of Europe because most countries either subsidize them directly or put a carbon emissions tax on fossil fuel use. In North America, pellets are not subsidized but often are used in wood stoves for their convenience and amenity value. Corn ethanol has received policy assistance in the United States for many years in the form of a $0.51 per gallon subsidy (recently reduced to $0.45), an import tariff, and a mandate to blend a certain percentage into gasoline.

The Energy Independence and Security Act of 2007 combines subsidies and mandates to promote greater use of liquid biofuels for domestic transport. The act requires a gradual increase in use of liquid biofuels by American fuel producers and sets a standard that started at 9 billion gallons of renewable fuel in 2008 and rises to 36 billion gallons by 2022. It also mandates a changing composition of biofuel use over time (Table 2). Of this total, 21 billion gallons must be advanced biofuel, which includes cellulosic biofuel making up 16 billion of the total. The act also creates a new set of subsidy incentives, adding a $1.04 per-gallon subsidy for cellulosic biofuel and decreasing the corn ethanol subsidy from $0.51 to $0.45.

The Energy Act, however, is not without ambiguities and limitations. Although the overall concept is to promote cellulosic biofuels, Congress appeared conflicted, and limited the sources from which the feedstock could be obtained. For example, Section 201 of the act includes a very restrictive definition of "renewable biomass" for the purposes of meeting the goals of the Renewable Fuel Standard. No biomass from forests on federal lands is allowable. Also, only "planted" trees in private forests are allowed. Thus, naturally regenerated private forests, even areas of active management, cannot be included. Slash and materials from precommercial thinnings are allowed, but only from nonfederal lands. Because only wood from nonfederal, private, planted forests is allowed, much of the U.S. forest estate is not available for biofuel feedstock.

Table 2. Required Volume of Wood for Producing the Cellulosic Biofuel Called for in the Energy Independence Act of 2007

Year	Volume	
	Billion gallons	Million cubic meters
2010	0.1	2
2011	0.25	5
2012	0.5	10
2013	1.0	20
2014	1.75	35
2015	3.0	60
2016	4.25	85
2017	5.5	110
2018	7.0	140
2019	8.5	170
2020	10.5	210
2021	13.5	270
2022	16.0	320

Note: The calculation of m^3, the common measure of industrial wood in the forest, uses a conversion of 1 m^3 wood = 0.6 tons mt, and 1 ton can produce 80 gallons of ethanol. Thus, 1 m^3 of wood produces approximately 50 gallons of cellulosic ethanol.
Source: Energy Independence and Security Act of 2007.

The Adequacy of Existing Timber Supply

Although Congress set these mandated targets for biofuels, the full implications of these levels of biofuels on feedstocks have not been well investigated. The principal sources of feedstock would be wood or grasses. Although grasses may prove to be a feasible long-term alternative, in the near term the onus of meeting the mandated targets would probably fall on wood because large inventories of wood and an infrastructure currently exist for harvest and transport; these are not available for grasses. It is clear that the timber harvest levels needed to supply both the conventional forest products industry and the new biofuel industry would be huge. For example, given commonly used conversion factors for wood to ethanol, the wood required for the targeted 2022 biofuel feedstock would need to equal to 348 million cubic meters (m^3) or 71 percent of the 2005 harvest of 489 million m^3 (UN FAO 2006). The United States produces about one-quarter of the world's industrial wood. Although, in theory, U.S. forests could probably sustain such an increase in physical harvest, the pressures and dislocations would be substantial. Of course, the limitations imposed by Congress on which wood would be acceptable for biofuels confound the supply problem.

A Dynamic Model

We used dynamic model is used to estimate the impacts of the Energy Act's mandates on wood use, price, and trade. The model is a variant of the dynamic timber supply model, TSM (Sohngen et al. 1999) and thus is more comprehensive than the simple static model in our previous example. We compared the base case output and prices of the TSM (that is, without any mandated cellulosic biofuel targets) with a model scenario that included the mandated increases under the Energy Independence and Security Act of 2007. These increases were assumed to be met by raw wood and therefore required an increase in wood demand to meet the mandated cellulosic ethanol consumption level.

The model investigates the U.S. mandated cellulosic requirements to 2022 and extends the implications to 2050. Figure 3 gives projections of wood prices in both the base case (that is, without increased demand for wood attributable to cellulosic biofuel production) and the case where the cellulosic mandates of the Energy Act are met solely by wood, thereby shifting out the demand for wood. Using the dynamic TSM projections, this approach suggests that U.S. and world raw wood prices would be about 15 percent higher in 2015 and about 20 percent higher in the early 2020s than they would be without the increased demand for wood for mandated ethanol production.

The figures do not include a representation of the difficulties resulting from prohibition of using wood from certain U.S. forests for biofuels as stipulated in the act. Also, the simple model generated estimates of the effect of the added demand mandated by the act, but did not consider the effects of increased wood pellet demand.

Figure 3. Wood Prices: Base and with Biofuels

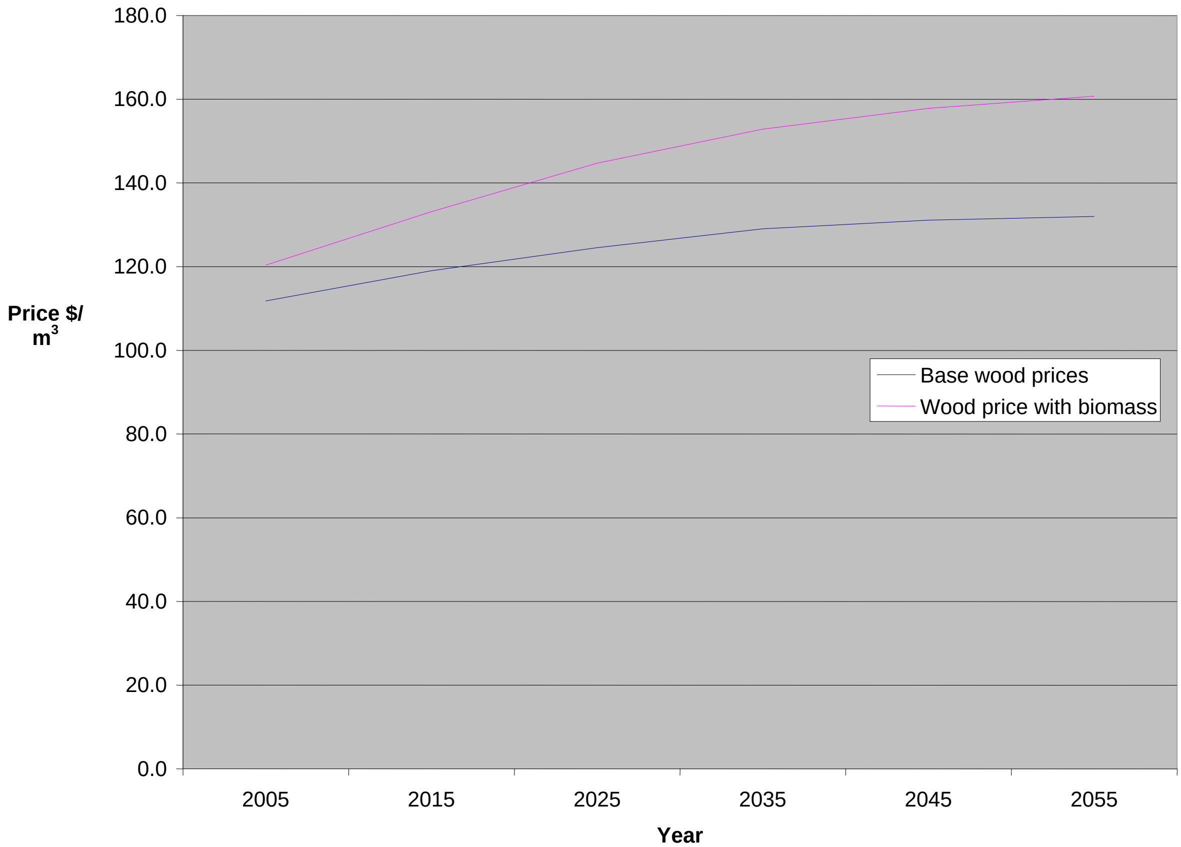
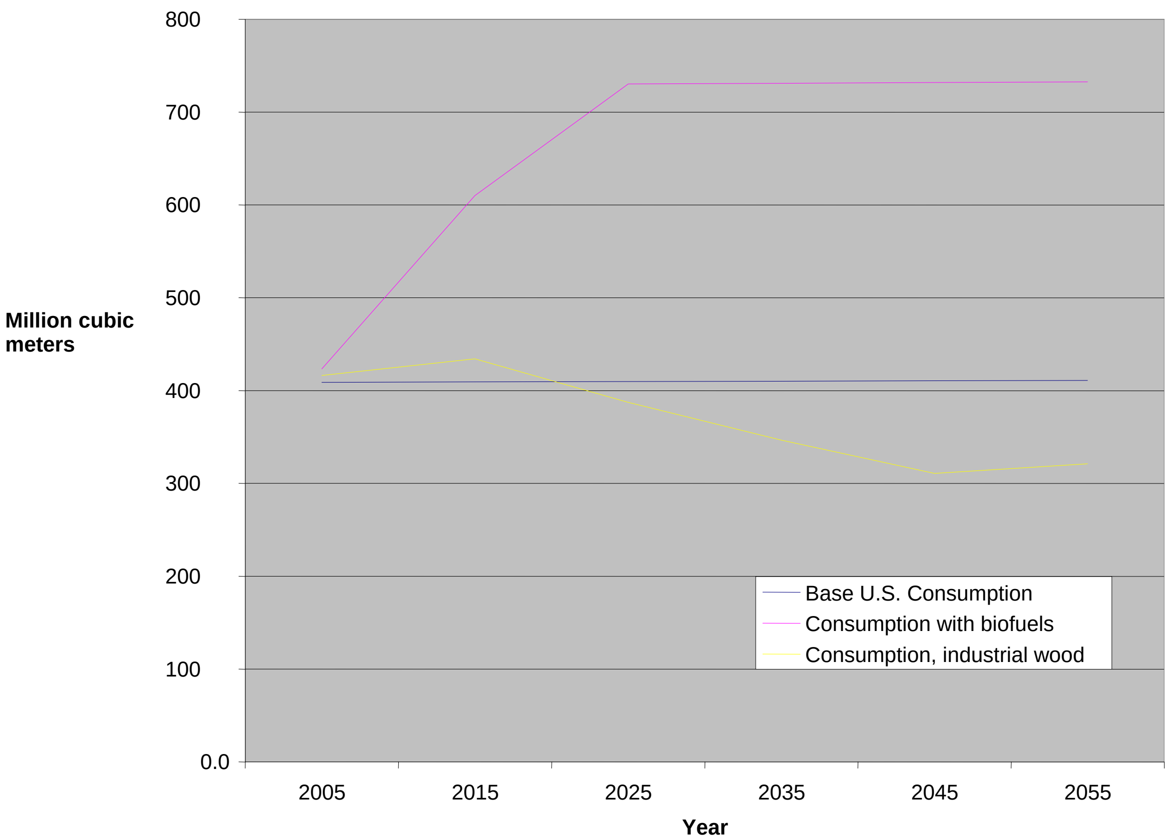


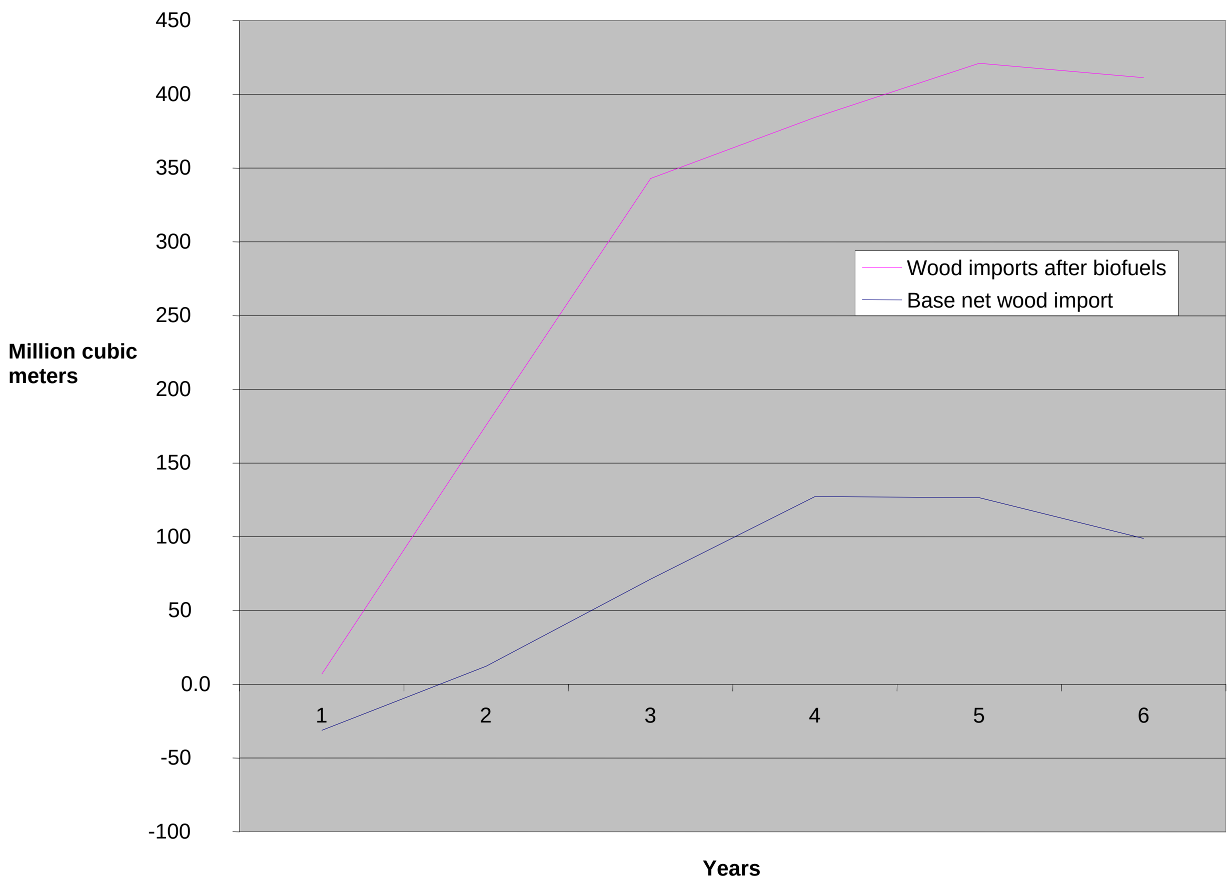
Figure 4 compares U.S. consumption of industrial wood with a base case with no wood use for biofuels and with wood use for cellulosic biofuels. The projections show biofuel use increases wood consumption by about 60 percent by the early 2020s. In the short run, the price run-ups in the United States would most likely be greater. The higher prices choke off some of the increased consumption of wood for conventional uses that would have occurred. Thus, the anticipated 71 percent increase is reduced to 60 percent because of the higher wood prices. The difficulties introduced by the large areas of forest prohibited for biofuel use (not specifically introduced into the model analysis) would probably generate higher harvest and transport costs and thereby would modestly increase the market above that projected.

Figure 4. U.S. Wood Consumption



Finally, Figure 5 examines the effects on the U.S. trade balance of meeting the mandated cellulosic biofuel production using wood. In the base case, the model projects movement from net exports of about $250 million in 2010 to a wood trade deficit (net import) of about $1.2 billion by 2050. In the mandated cellulosic biofuel case where the feedstock is all wood, net wood imports grow from roughly zero in 2010 to more than $4 billion by 2050. These trade flows reflect the wood values in a variety of processed wood products as well as raw wood flows.

Figure 5. U.S. Net Wood Products Imports



Summary and Conclusions

We've examined issues related to the use of biofuels generally with a focus on the implication of the Energy Act and its mandates for the wood market. The financial feasibility of wood energy in general and cellulosic liquid biofuels in particular depends on a host of factors—especially the price of alternative energy sources, including fossil fuels; the efficacy of using the wood resource for energy; government policies, including subsidies, mandates, carbon penalties, and other restrictions; the costs of the feedstock; and processing costs. Current legal limitations on which forests are eligible for renewable energy credits further confound the question of the future role and implications of cellulosic biofuels because they could substantially increase the cost of the wood feedstock and or its transport.

The effect of the Energy Act would be similar to that of the advent of a corn ethanol industry. Adding the demand for wood biofuel feedstock to the conventional demand for industrial wood would increase the prices of the wood feedstock. Using a dynamic timber supply model, we assessed the effects of the Energy Act mandate on wood prices, consumption, and trade. The modeling exercise suggests that the mandated increases in cellulosic biofuels of the Energy Act will raise wood prices about 15 percent higher in 2015 and about 20 percent higher in the early 2020s than they would have been without the increased demand caused by the mandates of the Energy Act. The modeling also projects a 60 percent increase in consumption of raw wood by 2022 and a sharp decline in the U.S. wood balance of trade compared to a base case. The model demonstrates that one of the major effects of biofuel demand on the wood market would be met by offshore wood production.

References

Bergman, Richard, and John Zerbe. 2008. Primer on Wood Biomass for Energy. http://www.fpl.fs.fed.us/tmu/wood_for_energy/primer_on_wood_biomass_for_energy.html (accessed October 17, 2008).

Colorado State University. 2007. Colorado State and USDA Scientists Find Significant Greenhouse Gas Reductions Associated with Biofuel Crop Systems. http://newsinfo.colostate.edu/index.asp?url=news_item_display&news_item_id=11182593 (accessed April 13, 2007).

Energy Independence and Security Act of 2007. Public Law 110–140. Dec. 19, 2007. http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110.pdf (accessed June 15, 2008).

Larson, E.D., S. Consonni, and R. Katofsky. 2003. *A Cost-Benefit Assessment of Biomass Gasification Power Generation in the Pulp and Paper Industry*. Report by Navigant Consulting, Inc., Princeton University, and Politecnico di Milano. Prepared for USDOE: Washington, DC.

Mandel, Jenny. 2008. Genetic Modifications Could Unlock Energy from Woody Plants. *Greenwire,* December 23, http://www.eenews.net/Greenwire/2008/12/23/9/ (accessed Dec 23, 2008).

McCarl, Bruce, and Tobias Plieninger. 2009. U.S. Bioenergy: Potential, Policy, and Economic/Climate Change Concerns. Chapter 1 in *Bioenergy in the United States and Germany*. AICGS Policy Report. Baltimore, MD: The John Hopkins University.

Newell, Richard G. 2006. What's the Big Deal about Oil? *Resources* 171 (Fall).

Perrin, R. 2007. Ethanol, Oil, and Corn. *Cornhusker Economics,* February 14.

Runge, C.F. and B. Senauer. 2007. How Biofuels Could Starve the Poor. *Foreign Affairs* May/June.

Searchinger, T., R. Heimlich, R.A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T. Yu. 2008. Use of U.S. Croplands for Biofuels Increases Greenhouse Gases through Emissions from Land-Use Change. *Science* 319(5867): 1238–1240.

Sedjo, Roger A. 1997. The Economics of Forest-Based Biomass Supply. *Energy Policy* 25(6): 559–566.

Sedjo, Roger A. 2008. Biofuels: Think Outside the Cornfield. *Science* 320(5882): 1420–1421.

Sjolie, Hanne K., Erik Tromberg, Birger Solberg, and Torjus F. Bolkesjo. Forthcoming. Greenhouse Gas Emissions, Policy Means and Increased Use of Wood Fuels in Norway. *Forest Policy and Economics*.

Sohngen, B., R. Mendelsohn, and R. Sedjo. 1999. Forest Management, Conservation, and Global Timber Markets. *American Journal of Agricultural Economics* 81(1): 1–13.

United Nations Food and Agriculture Organization (UN FAO). 2006. *Yearbook of Forest Products 2006*. Rome: UN Food and Agriculture Organization.

Wild, Michael. 2008. The Pellets Market in Europe. Presentation prepared for European Pellets Roadmap up to 2020 Workshop. http://www.aebiom.org/IMG/pdf/Wild_EBES.pdf (accessed May 15, 2008).