



**December 2009**  
**Volume 47 Number 6**  
**Article Number 6FEA7**

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# **Bioenergy from Woody Biomass, Potential for Economic Development, and the Need for Extension**

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**Abstract:** This article reviews the economic impacts of woody biomass utilization for bioenergy development and the role of Extension. Woody biomass is an alternative to reduce foreign oil dependency and mitigate greenhouse emissions. It is renewable, abundant, and can be virtually produced everywhere. Studies suggest that recovery of woody biomass, construction, and operation of biofuels or biopower facilities are a reliable source of employment generation and bring additional income to local communities. Extension should focus on the analysis of areas with the greater potential (e.g., feedstock, infrastructure, and labor availability) to promote sustainable woody biomass utilization.

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## Introduction

Recent fuel-development strategies to reduce oil dependency, mitigate greenhouse gas emissions, and utilize domestic resources have generated moderate interest in the search for alternative sources of fuel supplies (USDE, 2006). Woody biomass, the fibrous and generally inedible portions of stems and branches of plants, is one alternative energy source because it is renewable, abundant, and can be produced virtually everywhere (Hamelinck, van Hooijdonk, & Faaij, 2005; USDE, 2006; Solomon, Barnes, & Halvorsen, 2007).

Cellulose and hemicellulose, the main compounds of woody biomass, are made of energy-rich sugars that after pretreatment with hydrolysis and fermentation procedures can be converted to ethanol or fired to produce electricity in power plants. Woody biomass is found in a very diverse and widespread resource base that includes low-value forest products, such as logging residues, thinnings, urban waste, and mill residues among others (Perlack, Wright, Turhollow, & Graham, 2005). Frequently, part of this material is left on site, piled, and burned at additional cost, or left on site to decompose.

As pressure for green energy develops, more projects have been initiated to process woody biomass for fuels, electricity, and heat generation (Giampietro, Ulgiati, & Pimentel, 1997; Graf & Koehler, 2000; Ismayilova, 2007; Solomon, Barnes, & Halvorsen, 2007). Examples of woody biomass projects for bioenergy conversion, as opposed to grains or dedicated feedstocks, exist in Georgia, Oregon, California, South Carolina, and Canada among others (Gan et al., 2008).

A question remains about the economic impacts that bioenergy development would produce in a region's economy. These impacts, generally estimated in terms of value-added, output, and employment, are often borrowed from literature, other forest products industry projections, or from quick estimates. The limiting socioeconomic factors in recognizing and developing bioenergy include sustainability of resource base (USDE, 2006), little economic importance to a local or regional economy (Mayfield, Foster, Smith, Gan, & Fox, 2007), and uncertainty around investment in new technologies (Coleman & Stanturf, 2006; USDE, 2006).

This article presents a review of socioeconomic factors that affect the potential development of bioenergy. The primary goal is to discuss the economic impacts of woody biomass use as a feedstock for biofuels and biopower development and the role for Extension personnel to inform forest landowners, local and regional governments, and economic development agencies about the potential of using woody biomass for bioenergy.

## What Is Bioenergy?

Bioenergy is the solar energy stored via photosynthesis in organic matter. While this definition implies plant-converted energy, the concept also includes animal and food processed wastes (Perlack, Wright, Turhollow, & Graham, 2005). Electricity (biopower), liquid fuels (biofuels), and heat generated from biomass are examples of bioenergy. The first two are primarily considered for larger scale development due to existing processing capacity and the increasing demand for residential and industrial uses (Cook & Beyea, 2000).

Electricity generated from biomass operates in a similar way as fossil fuel-based plants. Instead of fossil fuels, however, biomass is direct-fired in a boiler to produce high-pressure steam that rotates a turbine, which in turn is connected to an electric generator. The majority of power plants are direct-fired systems, but some plants use a combination of coal and biomass feedstocks, a process called "co-firing." Co-firing systems have demonstrated that combining coal and biomass for electricity generation increases boiler efficiency, reduces

fuel costs, and significantly decreases emissions of nitrates and carbon (Demirba, 2003).

Biofuels are liquid or gaseous fuels that are produced from biomass feedstocks. Bioethanol, biodiesel, biogas, and hydrogen fuel are some examples of biofuels. Bioethanol and hydrogen fuel are produced through microbial fermentation of sugar, starch, and cellulosic materials. Biodiesel is made by combining alcohol (usually methanol) with vegetable oil, animal fat, or recycled cooking grease. Biogas is produced through anaerobic digestion of volatile organic compounds (NREL 2007). Ethanol is the most common biofuel produced from cellulose and hemicellulose. Ethanol has been in the center of political debates as it was announced as a serious alternative fuel to displace 30% of the nation's current fossil oil use by 2030 (USDE 2006).

Current technology, based on dilute acid pretreatment and fermentation, can produce up to 80 gallons of ethanol from one dry ton of woody biomass (Hamelinck, van Hooijdonk, & Faaij, 2005). To meet the 2030 goals, it would be necessary to produce 60 billion gallons of cellulosic ethanol a year, which requires one billion dry tons of woody biomass in supplies. Nation-wide studies estimate that current woody biomass potential is about 1.3 billion dry tons per year, enough to cover the 2030 energy goals (Perlack, Wright, Turhollow, & Graham, 2005).

## **Economic Impacts of Bioenergy & Input-Output Models**

The economic impacts of bioenergy are generally analyzed for three socio-economic indicators: gross output, value-added, and employment (Gan & Smith, 2007). In evaluating the impacts in a region's economy, input-output models are often used for the appraisal. Output represents the total value of production; value-added is total output minus costs of purchased inputs and represents the amount of money available for disbursement, either in the form of wages, owner compensation, or taxes; and employment includes the number of full and part-time jobs in the sector (Shaffer, 1999). Evaluation of these indicators can help decision makers develop strategies oriented to establishing energy transformation centers in a specific region.

Input-Output (I-O) models are planning tools frequently used to assess economic impacts of industries or commodities on a region's economy. I-O models provide multipliers that estimate the relationship between the initial effect of a change in final demand and the total effects of that change. These effects, which can be direct, indirect, or induced, describe the change of output for each and every local industry caused by a one dollar change in final demand (Rickman & Schwer, 1995).

Direct effects measure the changes associated with the immediate impacts in the level of production of an economic activity, such as the dollar value of output produced by a new cellulosic ethanol plant. Indirect effects are the production changes in other sectors of the economy resulting from a direct effect generating various rounds of re-spending in other industries. For instance, a cellulosic ethanol plant requires a considerable amount of chemical and biological materials such as sulfuric acid and cellulase enzymes to process woody biomass. Changes in sales, jobs, and income in the cellulosic ethanol industry are direct effects. Changes in sales, jobs, and income in the chemical industry represent indirect effects of changes in ethanol production. The chemical industry, in turn, requires inputs from other industries that represent another round of indirect effects. Indirect effects disappear gradually until leakages stop the cycle.

Induced effects are the changes in economic activity resulting from household spending of income earned directly or indirectly as a result of bioenergy conversion. Cellulosic ethanol and chemical industry employees spend their earned income for housing, food, transportation, health, and education. The sales, income, and jobs that result from household spending of added wage, salary, or proprietor's income are induced effects.

Various types of multipliers have been developed to measure the effects and the economic activity analyzed (i.e., output, value-added, employment, and income) (Rickman & Schwer, 1995). Type SAM multipliers are estimated by adding direct, indirect, and induced effects and dividing by the direct effects. They usually are preferred to other types of multipliers because they account for social security and tax leakages, institutional savings, and interinstitutional transfers. Large multipliers indicate greater impacts for a local economy.

Previous applications of I-O models have demonstrated the multiplicative effects of bioenergy in various regions of the U.S. (CEC, 2001; Hjerpe, 2006; REMI, 2006; Gan & Smith, 2007; Grebner, Perez-Verdin, Sun, Munn, Schultz, & Matney, 2009). Studies indicate that the single activity of recovery of all available logging and thinning residues would create a significant number of jobs and stimulate rural economies (Hjerpe, 2006; Gan & Smith, 2007). Gan and Smith (2007) estimated Type SAM multipliers of 2.0, 1.7, and 2.1 for value added, gross output, and employment, respectively (Table 1). The multiplier effect indicates that every dollar's worth of initial stimulus in the recovery of logging residues results in an additional dollar of value added and for every dollar of gross output, \$0.70 worth of indirect and induced output is generated in other sectors. Similarly, for every job created in the recovery of logging residues, 1.1 jobs would be created in other sectors or industries.

Important benefits are also expected from the construction and operation of biofuels or biopower facilities. Economic multipliers of biopower and biofuels estimated by Gan and Smith (2007) and REMI (2006) demonstrate that bioenergy development is also a reliable source of employment generation (Table 1). Both studies found employment multipliers over 5, meaning that for every job created in any of these industries, four more jobs would be created elsewhere. Biopower, however, has the unique advantage over biofuels because existing coal-fired power plants can be easily modified to allow use of wood for electricity generation. This not only represents considerable savings in construction costs but important environmental benefits as well. Wood offsets carbon dioxide, sulfur dioxide, nitrogen oxides, and other emissions generated by the otherwise use of coal (Ismayilova, 2007).

**Table 1.**  
Economic Impacts of Bioenergy in Different Areas of the U.S.

Group	Region	Multipliers		
		Output (\$)	Value Added (\$)	Employment (# of jobs)
Recovery of logging residues	East TX <sup>1</sup>	1.67	2.00	2.15
	MS <sup>2</sup>	1.86	2.62	2.92
Procurement of small-diameter trees (thinning) <sup>3</sup>	AZ, NM, CO	1.30-1.60	NR	1.45
Cellulosic ethanol	MI, MN,	1.55	NR <sup>5</sup>	5.75
	WI <sup>4</sup>	1.62	2.27	1.93
	MS <sup>2</sup>			
Electricity generation	East TX <sup>1</sup>	1.35	1.32	5.20
	MS <sup>2</sup>	1.60	2.33	2.25
Sources: <sup>1</sup> (Gan & Smith, 2007), based on 1.3 million dry tons of woody biomass				

<sup>2</sup> (Grebner, Perez-Verdin, Sun, Munn, Schultz, & Matney, 2009), based on 4 million dry tons of woody biomass, 52 million gallon ethanol plant, and 100 MW biopower facility

<sup>3</sup> (Hjerpe, 2006)

<sup>4</sup> (REMI, 2006). Multipliers were estimated using REMI Policy Insight models and include construction costs for a 52 million gallon ethanol plant.

<sup>5</sup> Not reported

Even though impact multipliers are difficult to compare across regions, because they depend on regionalized socioeconomic structures, these studies indicate that bioenergy is a serious alternative to help diversify and improve regional economies in many rural areas of the country (Domac, Richards, & Risovic, 2005; Hjerpe, 2006; Gan & Smith, 2007). Regions with low multipliers, but rich in natural resources, can greatly benefit from bioenergy development. These areas can achieve social cohesion and community stability as new jobs and income-generating sources are created (Domac, Richards, & Risovic, 2005). Furthermore, their multiplicative effect and expenditure retention should increase as technology, equipment, and human capital are gradually attracted to the area (Hjerpe, 2006). Recent research on the economic impact and multiplier effect of bioenergy summarized in Table 1 can be used to demonstrate the potential economic impact of woody biomass on local economies.

## What Is the Role of Extension?

For many regions, lack of information has been a limiting factor in developing local woody biomass and bioenergy markets. Many landowners do not recognize the potential of future markets to utilize products once considered waste and the benefit of having additional income. Local and regional government officials often are not aware of the potential economic impacts to local economies resulting from bioenergy development. For landowners and local government agencies, woody biomass and bioenergy are both separate but highly related information-deficient areas that can be improved by the services that Extension can provide. On the one hand, landowners need information to recognize woody biomass as a source of income. On the other hand, local government agencies, from an economic development standpoint, also need information to justify the pursuit of bioenergy conversion for increasing employment, taxes, and real disposable personal income.

Bioenergy development would create a market for landowners' woody biomass (e.g., logging residues) and attract other industries that would supply bioenergy needs on equipment or technology. This means more resources coming to the area and higher expenditure retention. Extension can help to promote woody biomass utilization in areas with extensive woody biomass supplies, labor, and infrastructure. Extension should focus on developing strategies to increase landowners' awareness of woody biomass utilization. The combined efforts of state and county level Extension personnel can also serve as an information conduit between landowners and local and regional government and economic development officials.

Extension can help bridge this information gap by educating landowners of potential woody biomass markets and helping local government and economic development officials realize the local woody biomass resource base that can be developed into a new local industry through bioenergy production. The bioenergy market is rapidly developing, and local and regional economies can benefit if they take the economic development initiative. But first they must understand the importance of the industry, the local resource base, and the economic development potential of bioenergy. All of these are primarily information-based needs that Extension is well suited to provide.

State- and county-level Extension personnel are trained at the bachelor or graduate level in biological sciences, agriculture, social sciences, or natural resource economics. This combination of expertise offered by Extension is necessary to provide education in the area of bioenergy based economic development. Education programs such as landowner short courses and workshops are an excellent means to inform landowners about existing and potential markets for logging residues as biomass for bioenergy. Woody biomass sources can also include direct production using coppice management, where stands of tree species that root sprout are periodically harvested to meet wood biomass production needs. Landowner short courses can be developed to focus on a variety of wood biomass production methods highlighting management practices and economic analysis of such investments. Currently, forestry Extension personnel have expertise in conducting pine productivity workshops and short courses (Londo & Monaghan, 2002; Londo, 2004; Cason, Grebner, Londo, & Grado, 2006). Modifying these workshops to incorporate woody biomass production information would compliment existing materials.

In terms of economic development support, Extension specialists in agricultural and natural resource economics can develop and disseminate regional economic impact analyses of biomass and bioenergy conversion. This can help local level economic development efforts where such experts are not employed at the local government level. The use of information sheets, short courses, or workshops for local government officials can help to achieve such local efforts. Another important tool that Extension agents could use for this process is eXtension. This Web-based venue is well suited to serve as a conduit for individuals and communities to exchange information and experiences across the country. These activities will enhance economic development efforts allowing local officials to market their location for bioenergy conversion facilities.

## Conclusions

Woody biomass and the conversion of bioenergy is a rapidly developing new energy market. Many rural economies could potentially benefit as this industry develops, provided they are proactive in the economic development of such opportunities. Important benefits are expected on a region's economy with the generation of expenditures, taxes, and employment as a result of bioenergy development.

State- and local-level Extension personnel are well suited to provide information to both landowners and governmental officials. The potential exists for collaborative efforts among landowners, local government officials, and county and state Extension personnel to develop and promote an emerging market for woody biomass-based bioenergy. Recognizing this opportunity will generate additional opportunities for Extension personnel at the state and county level to work together to create programs and educational materials for their clientele. Extension is poised to seize the opportunity to create new and potentially innovative programs at a pivotal time in energy development that can result not only in the betterment of local economies but also create new opportunities for county and state level Extension personnel to serve our constituency.

## Acknowledgements

We would like to thank the Department of Forestry and the Forest and Wildlife Research Center (FWRC) at Mississippi State University for the use of facilities and resources. This manuscript is publication number FO369 of the FWRC, Mississippi State University.

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