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# Factors affecting public support for forest-based biorefineries: A comparison of mill towns and the general public in Maine, USA

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## HIGHLIGHTS

- We examined social views of bioproducts processing in mill towns and statewide.
- Environmental sustainability was a major concern expressed by both samples.
- Views were affected by proximity to processing, and by respondent characteristics.
- Public concerns should be considered along the entire supply chain.
- Views toward biorefineries may be influenced by views of related industries.

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## ABSTRACT

Community views toward the risks and benefits of emerging renewable energy technologies are important factors in facility siting decisions and their eventual success. While the actual socioeconomic and biophysical impacts of proposed industrial developments are fraught with uncertainty, understanding public perceptions is critical in managing costs and benefits to local citizens. Here, we explore the social acceptability of forest-based biorefineries in Maine using random utility modeling to identify how project attributes and citizen characteristics interact to affect level of support. Using a statewide sample (Statewide) and a subsample of mill towns (Mill Towns), we found that: (1) in both samples, individual characteristics had similar coefficients and significance levels except for pro-environment attitudes; (2) the coefficients related to the industry's negative attributes were notably different between the two samples, while positive attributes were not; (3) in both samples, positive industry attributes such as "producing products from a sustainable resource" and "increased economic development" were the most influential variables in determining the level of support for a new biorefinery in an individual's community; and (4) in general, Mill Town respondents were more accepting of potential negative attributes such as increased levels of truck traffic, odor, noise, and air and water pollution.



## 1. Introduction

### 1.1. Background and study objectives

Major efforts are underway around the world to reduce fossil fuel consumption to lower greenhouse gas (GHG) emissions and mitigate global climate change. In the U.S., the 2007 Energy Independence and Security Act (EISA), coupled with subsequent amendments, has focused efforts on replacing fossil fuels with domestic renewable energy sources—especially in the transportation sector, which accounted for 27.8% of total U.S. energy use in 2011. Currently, nearly 93% of transportation energy consumed in the U.S. is petroleum-based (U.S. Department of Energy, 2013).

Ethanol has received much attention as a gasoline additive, and the U.S. in recent years has invested more than any other country in ethanol production (Curtis, 2008). Currently, the vast majority of U.S. ethanol is derived from corn grain as a feedstock, and ethanol consumption in the U.S. has increased from 1.1 billion gallons/year (BGPY) in 2000, to 8.6 BGPY in 2010 (U.S. Department of Energy, 2013). Yet as corn-based ethanol production has expanded, public support regarding its suitability as a renewable fuel source has waned (Arnold, 2008). The longstanding "food versus fuel" debate continues (Brown, 1980), with added concerns over water use and

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net energy balance (Curtis, 2008), as well as impacts on land conversion rates from natural cover to agricultural systems (Kim et al., 2009).

As an alternative, cellulosic biofuels are viewed by many as the next phase in the development of bio-based liquid transportation fuels. Cellulosic biofuels, as opposed to grain-based ethanol, use primarily non-edible feedstock materials such as corn stover, switchgrass, woodchips, and woody biomass. These feedstocks avoid many of the social concerns attributed to corn-based ethanol because they are largely derived from waste materials or byproducts of agricultural and forestry activities. Moreover, Wang et al. (2011) found that cellulosic biofuels from forest residues have minimal impact on land use as compared to corn or other agricultural feedstock-based fuels.

Since 2007, the U.S. Department of Energy (2007) has committed billions of research and development dollars across an array of programs to expedite the development and commercialization of advanced biofuel technologies, especially cellulosic biofuels. EISA mandated the domestic production of 36 BGPY of biofuels by 2022, out of which 16 BGPY are to be derived from cellulosic feedstocks. Moreover, under recent EISA amendments, the Renewal Fuel Standard (RFS2) requires the use of renewable fuels such as cellulosic ethanol and advanced biofuels—especially those produced from cellulosic biomass. RFS2 endorses the life cycle GHG emissions performance reduction thresholds of bioethanol established by EISA (i.e., 20% to 60% reduction compared to the life cycle emissions of 2005 petroleum baseline fuels). Similarly, cellulosic biofuels are required to have a reduction of 60% life cycle GHG relative to the GHG emissions that the fuel replaces (EPA, 2007).

A major technical challenge for cellulosic biofuels, however, is the difficulty of converting lignocellulosic materials into drop-in liquid biofuels. Drop-in biofuels resemble the properties of petroleum fuels and can be transported without any modification of existing infrastructure (Hsu, 2012). At present, this conversion process is considerably more challenging in terms of net return and cost than that of corn-based processing (Arnold, 2008). Beyond this technical challenge, other obstacles remain, including logistical hurdles surrounding the collection and transportation of feedstock to conversion facilities, as well as product storage, marketing, and distribution.

Collectively, these challenges have limited production, and in response the cellulosic portion of the RFS2 biofuels mandate has not been enforced over the past four years, creating uncertainty in the industry and setting a nationwide precedent of not enforcing biofuels regulations. Aside from production challenges, cellulosic biofuels face other hurdles—e.g., some agricultural feedstocks have use as animal fodder, and woody biomass intended for biofuels may compete with other wood-using industries such as combined heat and power in the lumber sector. And for both forest-based and agricultural products, long-term impacts on soil health are largely unknown. In forests, for example, impacts are likely to vary depending on the amount and type of harvest-generated residue remaining on-site after logging (Benjamin, 2010).

Because cellulosic biofuels can be derived from a wide range of feedstocks, increasing production on the scale envisioned under EISA is likely to affect areas well beyond the Midwestern “corn-belt” and have broad regional impacts. And just as social concerns developed over time regarding grain-based ethanol, increased cellulosic biofuel production may spur similar concerns over feedstocks and other conversion inputs, as well as manufacturing processes.

Maine, as well as other heavily forested regions of the U.S., is particularly well-suited for cellulosic biofuels projects, offering rural communities an opportunity to support long-established forest-based processors, generate jobs and income, and diversify local economies (Curtis, 2008). Here, we used a mail survey of Maine residents to better understand how they view the potential positive and negative impacts of processing woody biomass from forest residues into cellulosic biofuels. We surveyed residents both statewide and in mill towns with existing pulp and paper manufacturing facilities because such mills are likely to serve as sites for the co-location of forest-based biorefineries (Dickerson and Rubin, 2008). Our intent was to identify key variables affecting social acceptability of this emerging industry in order to better inform policy debates over the tradeoffs between renewable energy and environmental protection.

### 1.2. *Forest-based biofuels*

The USDA and DOE estimate that 33 to 119 million dry tons of forest residue biomass could be sustainably provided by U.S. forests at prices of $20 to $80/dry ton roadside (U.S. Department of Energy, 2011). By definition, forest residues are comprised of biomass remaining after forest thinning and harvesting operations, and thus do not directly compete with pulp-and-paper, lumber, composite panel furnish, and other commodity timber products. In some cases, utilizing these materials may actually complement forest operations by creating new markets for previously unmerchantable material.

Production of woody biomass-derived cellulosic biofuels adjacent to existing pulp mills can utilize forest residues as well as fractions of wood chips and recycled paper not used in the pulping process. While technological and economies-of-scale issues remain, the Agenda 2020 Technology Alliance’s “Value Prior to Pulping” (VPP) project is evaluating the extraction and conversion to ethanol of hemicelluloses from wood chips prior to pulping. Under this model, cellulosic ethanol and bio-oil would be produced in a “biorefinery” co-located with existing pulp and paper mills. These side facilities would operate much like traditional petroleum refineries, except that biomass would be used as the feedstock instead of crude oil (Benjamin et al., 2009; Mao, 2007). Woody biomass not suitable for pulp and paper would be processed into fermentable sugars that could be made into cellulosic ethanol, butanol, and other bio-based products.

Maine, located in the northeastern United States, offers considerable opportunities for establishing capacity in cellulosic biofuels production due to its extensive forests and well-established and diversified forest products processing industrial base (Benjamin et al., 2010; Dickerson and Rubin, 2008; Lilieholm et al., 2011; Milbrandt, 2005). Ninety percent of the state is in forest cover. The state’s established pulp and paper industry, comprised of nearly a dozen kraft and groundwood pulp processing mills, is especially important due to the growing consensus that biorefineries could be “co-located” with existing pulp and paper mills (Biorefinery “Financial Case” Team, 2007; Larson et al., 2006; Mao, 2007; van Heiningen, 2006). Several studies have examined the economic feasibility of forest-based biorefineries in Maine (Biorefinery “Financial Case” Team, 2007; Dickerson and Rubin, 2008). Although the investment needed to augment an existing paper mill with a biorefinery would be substantial, benefits include an existing feedstock supply network, an established workforce, and reduced permitting given existing mill infrastructure and the availability of many utilities and services (e.g., water, waste storage and disposal, energy sources, etc.) (Dickerson and Rubin, 2008). These benefits, coupled with new employment opportunities and an enhanced product mix, could economically justify the investment, although Dickerson and Rubin (2008) found that profitability is highly dependent on oil prices.

As technological and economic studies advance efforts to develop the cellulosic biofuels industry, the social acceptability of establishing and operating a forest-based biorefinery becomes increasingly important (Bergmann et al., 2007; van der Horst, 2007). Indeed, just as social concerns over corn-based ethanol spurred significant changes in energy policy (including EISA’s cellulosic mandate), forest-based biorefineries will likely have