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Biofuels Development in Maine:

Using Trees to Oil the Wheels of Sustainability

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As national standards require increased use of renewable transportation fuels by 2022, Maine is positioned to be a leader in wood-based cellulosic ethanol production and use. Caroline Noblet, Mario Teisl, Katherine Farrow, and Jonathan Rubin consider Mainers' willingness to accept and use biofuels. They document the current level of consumer knowledge and behavior and identify factors (environmental, economic, and energy security) that may assist or constrain drivers from purchasing biofuels. 🐉

INTRODUCTION

The Rise of Biofuels

The Energy Independence and Security Act of 2007 (EISA) mandates the sale of renewable energy and advanced biofuels through the Renewable Fuel Standard (RFS). This standard requires 36 billion gallons of renewable transportation fuel by 2022, with 21 billion provided by advanced biofuels. It is estimated that three-quarters of the requirement will be from cellulosic ethanol, a form of ethanol produced from plant fiber (cellulose), where sources may include trees, switchgrass and scrap wood (Sissine 2007). With the help of the RFS and a \$0.46 per gallon tax credit and a \$0.54 per gallon tariff on imported ethanol (Kish 2012), U.S. production capacity of corn-based ethanol swelled to 13.5 billion U.S. gallons in 2010 (Renewable Fuels Association 2011). Recently, the subsidy for corn-based ethanol and the import tariff were eliminated; however, according to an article by Miguel Llanos on the NBC News website (nbcnews.com), a \$1.01 per gallon tax credit for the production of cellulosic ethanol remains in place. These ambitious production targets and changing system supports yield the need for “rapid build-up in production capabilities...for cellulosic biofuels” (USDA 2010: 18), given that cellulosic ethanol production is “far below” the EISA revised targets (EIA 2102a: 1). In addition, there is concern that reaching consumption targets set under the RFS will be challenging (EIA 2012b).

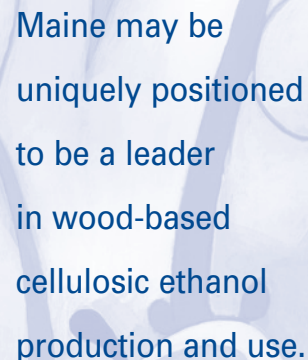
Given the above, there is an increased interest in the potential for cellulosic ethanol from wood products (Solomon et al. 2007; Solomon and Johnson 2009). Cellulosic ethanol has a better carbon footprint than either traditional fuel or corn-based ethanol (Rostrup-Nielsen 2005), and its production does not lead to higher food prices like other sources of ethanol (i.e., corn and sugarcane). In addition to the environmental benefits of ethanol production and use, there are substantial economic and energy-security benefits. For example, the U.S. currently imports 49 percent of its petroleum requirements (EIA 2011), some of this coming from relatively unstable nations. One way to reduce the negative impacts of the volatility of oil prices on the transportation sector is to substitute

domestically produced biofuels for imported oil.

However, there are several substantial technology and infrastructure hurdles limiting greater market penetration of these fuels. For example, outside of flex-fuel vehicles, most gasoline engines cannot use ethanol blends greater than 10 to 15 percent. The environmental benefits of some biofuels have come into question as impacts on deforestation have become linked to production of certain biofuels depending on feedstock and production process (Pimentel and Patzek 2005; Pimentel et al. 2009). Thus, it is important to consider not only technological barriers to increased consumption, but also citizen and consumer understanding of the differences in biofuels. Broad generalizations about the environmental and energy-security benefits of biofuels are not sufficient. There are substantial differences between them, with some having superior environmental benefits and others being similar to gasoline and diesel fuel. What is needed is a better understanding of consumers’ acceptance of production and consumption characteristics of different biofuels (Wegener and Kelly 2008).

The Potential for Maine

Maine may be uniquely positioned to be a leader in wood-based cellulosic ethanol production and use. The Forest Bioproducts Research Initiative (FBRI), a university/business partnership led and housed at the University of Maine, has leveraged multimillion dollar grants to develop solutions to overcome technological hurdles, including examining how wood can be transformed into ethanol, gasoline, heating oil and other substances (www.forestbioproducts.umaine.edu). Increases in investment and scale of these products may have impacts on Maine’s economy, environment, and people. The University of Maine has recently procured a National Science Foundation Sustainable Energy Pathways grant to further investigate the technological possibilities of wood-based cellulosic ethanol, along with the economic and environmental impacts that may accompany a scale-up of biofuels production in



Maine may be uniquely positioned to be a leader in wood-based cellulosic ethanol production and use.

Maine. Maine citizens may welcome a new output opportunity for the forest industry; alternatively, Mainers may react negatively to wood-based-fuel production if it leads to deterioration in forest management, congestion, pollution from the building and running of biorefineries (see Marciano et al. 2009), or transportation fuels with inferior characteristics. To develop optimal policies and understand the likelihood of successful Maine-based production, we must determine citizen understanding of, and willingness to support, wood-based cellulosic ethanol; previous work has noted that discussion of citizen perceptions and preferences may improve decision making and potentially reduce conflict (Anderson et al. 2012).

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Here we consider Mainers' willingness to accept and use biofuels. Although there is little research on citizen or consumer opinions about biofuels, what little exists does not examine why people hold specific opinions (Delshad et al. 2010), and much of this research is in other countries, e.g., Belgium (Van de Velde et al. 2009); Greece (Savvanidou et al. 2010); or regions, e.g., Indiana (Delshad et al. 2010); Oklahoma (Ulmer et al. 2004). Although the economic, environmental, and fuel-security impacts of biofuels differ across source material (Pimentel 2003), consumers seem ignorant of these differences (Collantes 2010; Jensen et al. 2010).

Outside of a regulatory mandate, successful markets for cellulosic ethanol will require that production of the fuel is competitive with existing markets or consumers are willing to pay a premium for the product (Hite et al. 2008; Bhattacharjee et al. 2008;

Collantes 2010; Jensen et al. 2010). An important first stage in implementing marketing and education strategies is to document consumers' current level of knowledge, perceptions, and behavior; and to identify the factors (environmental, economic, and energy security) that may assist or constrain consumers from purchasing biofuels:

1. Do consumers realize ethanol is part of our fuel supply, and if so, what attributes do they associate with ethanol?
2. Will differentiation of biofuels by source provide information sufficient for consumers to identify preferred biofuels and introduce differing impacts as a driver of buying decisions?
3. To what extent do existing perceptions of biofuels and their attributes block consumers from considering biofuels as an appropriate substitute for gasoline?
4. In a forested state such as Maine, how do residents view the forest management issues and economic development opportunities caused by increased wood harvests to meet biofuel demand?

These questions serve as the primary motivation for the current analysis.

METHODS

Sampling and Survey Administration

During the summer of 2009 we administered a mail survey to a representative sample of 3,800 New England residents (500 residents per state, with an over sample of Maine residents, 800). The sample frame was purchased from InfoUSA, which maintains a database containing information about 210 million U.S. residents.

The survey was administered with multiple mailings, including an introductory letter sent by post return-receipt requested to identify undeliverable addresses. In total, 382 Maine residents and 958 New England (non-Maine) residents responded to the survey

for a response rate of 52 and 38 percent, respectively, yielding an overall response rate of 40 percent. Given that the number of respondents representing each state is not proportional to the states' representation in the New England population, we used a weighting procedure when aggregating our data to the New England level.

The characteristics of our respondents are different than the states' population characteristics according to the 2010 U.S. census data. Most notably, our survey respondents are more likely to be male, slightly older, and have higher education and incomes levels. In turn, we calculated weights to correct our respondent profiles to be more consistent with state census data. Specifically, we corrected for gender and education biases and, after weighting, found our income averages were much closer to the state averages. Given that the income and age results were not that different, we decided not to make corrections for these two variables.

Survey Questionnaire

The survey questionnaire was greatly informed by focus groups held in Maine and Massachusetts during the summer and fall of 2008 (Teisl et al. 2009). The final survey instrument consisted of six sections aimed at eliciting information regarding consumers' environmental concern (in general and regarding specific issues), including their experience with, or knowledge of, biofuels, with a specific focus on cellulosic ethanol production; driving habits; responses to environmental psychology constructs; a fuel-choice experiment; current environmental behaviors; and socioeconomic characteristics.

Most questions were phrased on a five-point rating scale, including environmental concern (1 = not at all concerned, 5 = very concerned) and the importance of benefits/concern regarding cellulosic ethanol and reasons to change driving habits (1 = not at all important, 5 = very important). Likert-type scales were used for questions about perceptions of/experience with ethanol (1 = strongly disagree, 5 = strongly agree). Environmental behavior questions were framed as frequency of engaging in the activity (1 = never, 5 = always), the exceptions being whether a respondent participates in an environmental group or efforts to reduce driving (yes/no). The survey also gathered infor-

TABLE 1: **Transportation Characteristics of Respondents**

	Maine	New England
Price/gallon	2.56*	2.64
Gallons/week	18.7*	14.6
Miles/week	235*	153
Percentage of weekly driving for commuting to work	44	45
Percentage carpooling to work	6	8
Percentage biking/walking to work	4*	9
Percentage using public transportation	2*	14
Percentage stating they try to drive less	75	67
Average importance ratings ^a of why they try to drive less:		
To save money	4.7	4.6
To reduce wear and tear on vehicle	4.0	4.0
To reduce oil imports	3.7	3.9
To reduce air pollution	3.5	3.8
To reduce global warming	3.1	3.5

^a Rating based on a scale from 1 = not at all important to 5 = very important.

* Indicates statistical difference between Maine respondents and other New England respondents (p = 0.05)

mation on existing driving habits (by activity), gallons of fuel used per week, average price per-gallon, and the type of fuel currently used in their vehicle.

RESULTS AND DISCUSSION

Driving Habits

To understand how consumer habits may change when wood-based cellulosic ethanol becomes commercially available, we need to establish a baseline of consumers' driving habits. Mainers in our survey spend less per gallon for fuel compared to the average New England driver (Table 1). Mainers drive more and use more fuel than the average New England driver. This result is not surprising given the cheaper fuel and the fact that much of New England is more urbanized than Maine. More urbanized areas tend to have more public transportation options; this explain why New Englanders, on average, are seven times more likely to report using public transportation.

TABLE 2: **Regional Concerns of Respondents^a**

Concerns	Maine	New England
Economy	4.6	4.6
Dependence on fuel imports	4.4	4.3
Forest management	3.8*	3.6
Amount of air pollution	3.7*	3.9
Global warming	3.6*	3.9

^a Rating based on a scale from 1 = not at all important to 5 = very important.

* Indicates statistical difference between Maine respondents and other New England respondents (p = 0.05)

TABLE 3: **Respondent Behaviors and Views Surrounding Imported Goods**

Behaviors and Views	Maine	New England
	----- % -----	
Buying behaviors^a		
Buy American-made products	51	55
Buy eco-labeled products	18	24
Attitudes and beliefs toward importing fuel^b		
It is a good idea to buy less imported fuel	88	85
Buying American-made fuel improves our economy	73	79
Importing fuel hurts our national security	44	43

^a Percentage of people stating more than “sometimes” including “always.”

^b Percentage of people stating they “agree” or “strongly agree with the statement.”

That Mainers are less likely to walk or bike to work is also likely due to differences in urbanization and that Mainers face longer and more severe winters than the average New Englander.

A majority of both groups try to drive less, and the top two motivations are economic (Table 1), where reducing fuel imports could be a security motivation as well as an economic one. In contrast, air-quality concerns are relatively unimportant in people’s driving decisions; although Maine’s average response on a five-point scale “to save money” (4.7) and average

response “to reduce air pollution” (3.5) do not seem particularly telling, statistical analysis reveals that these responses are indeed statistically different and require our attention. These results suggest that, even when biofuels have improved fuel security and environmental characteristics, price is likely to be the primary driver of fuel choice.

Concerns for the Region

Wood-based cellulosic ethanol has the potential to be marketed under three distinct messages: air-quality improvements over gasoline or other ethanol sources; improved local economic conditions (jobs, wages) due to production of cellulosic ethanol (from forest to refinery) in the Northeast; and national security benefits with ethanol produced domestically rather than reliance on foreign oil. To capture the issues of greatest concern to consumers and provide insight about messages regarding wood-based cellulosic ethanol that may resonate them, we asked consumers to express their concerns about regional environmental issues (air pollution, impacts of global warming, and use of forest resources), regional dependence on foreign fuels, and economic development concerns.

Mainers and New Englanders in our study are most concerned with the region’s economic growth, followed by regional dependence on foreign fuels, followed by the three environmental concerns (Table 2). Of these, forest management was a great concern of Mainers, while air quality was more important to the average New Englander. The ordering of these concerns indicates the reception of environmentally focused educational or marketing messages may differ across the region. Again, the primary concern for the region is economic, suggesting that economic messages will be the most powerful while messages about environmental improvements may be the least likely to resonate with consumers.

Relative Importance of Economic and Energy Security Issues

To refine our understanding of the relative motivations of Maine consumers, especially with respect to the issue of fuel security, we asked several questions about respondents buying American-made

or eco-labeled products and several questions to determine people’s attitudes and beliefs towards importing fuel. About half of all Mainers say they buy American-made products more often than “sometimes” (Table 3), whereas less than 20 percent stated they bought eco-labeled products with this level of frequency.

Most people have a positive attitude (“It is a good idea...”) to buy less imported fuel. Interestingly, the economic development benefits of buying domestic fuel are more important than the fuel-security benefits. Not surprisingly, a majority (58 percent of Mainers) state they cannot tell if the fuel they buy is imported, indicating that a marketing campaign promoting the economic development benefits of cellulosic fuel could be successful, especially if gas pumps were labeled with this information.

Knowledge and Perceptions of Ethanol

What people know about and how they view a new technology can have a great impact on consumer acceptance. We therefore asked several questions to measure respondents’ knowledge and perceptions of ethanol. We find almost all Mainers and New Englanders were aware of ethanol as a fuel additive (Table 4), and of those who were aware, almost all had heard that ethanol could be made from corn. Knowledge of other potential sources of ethanol (e.g., switchgrass, trees, and garbage) was relatively low and varied across the region, especially with respect to the knowledge that ethanol can be made from trees. Mainers were, not surprisingly, more aware of this potential source given that production facilities are more likely to be located here. In addition, there was some media attention, both positive and negative, surrounding the Red Shield research project in Old Town.

To capture whether consumers realized the fuel they currently use is a blend of 90 percent gasoline and 10 percent ethanol (i.e., E10), a survey question specifically targeted this knowledge: “What type of fuel do you typically put in your vehicle?” Remarkably, half of all Mainers believed they were using only gasoline, despite the fact that the Maine Department of Environmental Protection stated “by November 2008 nearly all the gasoline distributed in Maine... blended

TABLE 4: Respondent Awareness and Knowledge of Ethanol

	Maine	New England
Percentage hearing about ethanol as a fuel additive	91	87
Percentage indicating they know about ethanol sources ^a		
Corn	98	98
Soybean	38	26
Trees	37	21
Sugar cane	37	33
Switchgrass	27	27
Garbage	25	21
Construction waste	15	8
Paper production waste	13	7
Percentage thinking they use gasoline without ethanol	50	68

^a of those who indicated they had heard about ethanol

gasoline with 10% ethanol” (Maine DEP 2011). This knowledge of E10 in the fuel supply varied across the New England states, with southern New England respondents having higher awareness levels, probably due to the relative timing of the introduction of E10 into a state. A case in point, Maine transitioned to E10 fuel blends in late 2008 (Maine DEP 2011) only about seven months before the timing of the collection of the survey data. In contrast, New York, Connecticut and Rhode Island’s fuel supply has contained a substantial amount of E10 blends since 2004.

Inconsistent labeling of blended fuels may also have led to a lack of consumer knowledge regarding the fuel supply in their own and neighboring states. Labeling requirements for ethanol used as a blend agent vary by state. In addition to different labeling requirements, the at-pump labels across states differ substantially, where some use the term ‘gasahol,’ and others may or may not use the entire word ‘ethanol’ or abbreviate to E10. Thus, the current labeling system does not adequately inform consumers about the contents of their fuel supply, which may in part explain the lack of awareness of some respondents.

Given the varied knowledge of ethanol in the Northeast, familiarity may be a key component in acceptance of alternative fuel resources. Thus, we also

TABLE 5: Respondents' Perceptions of Ethanol

Perceptions	Maine			New England		
	Agree	Uncertain	Disagree	Agree	Uncertain	Disagree
	----- % -----					
Ethanol is cheaper than gas	44	40	16	46	34	20
Ethanol damages engines	31	36	33	42	46	12
Ethanol improves acceleration	42	52	6	42	53	5
Ethanol lowers fuel efficiency	31	45	23	39	45	16
Ethanol produces less pollution	25	37	38	30	30	40

have an interest in identifying the types of information about biofuels and biofuel-related attributes that could be communicated to consumers. To best move forward with communicating information about biofuels, an understanding of consumer prior perceptions is required.

On the whole, Mainers and other New England respondents are uncertain about the attributes of ethanol as a fuel additive (Table 5), which suggests that many consumers have not made up their minds about ethanol. Almost half of both groups agreed that “ethanol is cheaper than gas” although many were uncertain. Mainers were evenly split about whether ethanol damages engines, whereas other New Englanders were more negative. Recent legislative efforts in Maine (L.D. 1320 2009–2010) attempted to provide a supply of E10-free gasoline for use by Maine citizens, in line with the prevailing perception that E10 damages small engines such as lawn mowers or recreational vehicles such as ATVs, snowmobiles, or boats. Differing media coverage of this legislative initiative may provide context for this regional difference.

Mainers were similar to the rest of New England in that, of those with an opinion, most agreed that ethanol improves acceleration. In reality, since ethanol has a relatively high octane rating (113) adding it to regular (87) or premium unleaded (93) leads to improved engine performance (EERE 2011). Mainers with opinions on this attribute (54 percent of survey respondents indicate a neutral response to this question) were relatively less likely than New Englanders to think that ethanol lowered fuel efficiency; although ethanol contains less energy than gasoline, at a 10 percent ratio (E10), it has little impact on fuel efficiency (EERE 2011).

One of the key environmental attributes that has been touted for ethanol is the production of less greenhouse-gas pollution (EIA 2012a, 2012b). Only 25 percent of Mainers thought that ethanol produces less pollution, while 37 percent expressed uncertainty. In reality, compared to gasoline, corn-based ethanol produces 19 percent less greenhouse gases, and cellulosic ethanol produces an 86 percent reduction (EERE 2011).

Thus, perceptions about ethanol are relatively negative or uncertain. However, many people have seemingly not formed a strong attitude, so attitudes appear to be still malleable. Hence, biofuel promoters (and detractors) have the opportunity to influence individuals' opinions through information and marketing programs.

In addition, our research indicates that perceptions of ethanol differed across people's knowledge of E10 in their fuel. In our data, those who were aware of ethanol's presence in their fuel were statistically more likely to attribute damage (or negative effects) to ethanol, while being less likely to believe in the benefits of ethanol. These respondents are more likely to agree that ethanol causes engine damage and lowers fuel efficiency, and are more likely to disagree that ethanol improves acceleration and produces less pollution. Those who do not realize they are currently using ethanol are more likely to believe that ethanol is cheaper than pure gasoline. In addition, we find differences across driving habits between these two consumer groups. Those who recognize ethanol is present in their fuel tend to drive more miles per week (average = 242 miles) than those who are unaware of ethanol's presence (average = 180 miles); those who purchase more gallons of fuel per week are statistically more likely to recognize that ethanol is present in their fuel.

Benefits and Concerns Associated with Biofuel Production

While product attributes are key components of consumer acceptance, the perceived impacts of biofuels production in the state is a primary driver of citizen acceptance. Here we seek to understand Mainers' reactions to different economic, fuel-security and environmental impacts of biofuels production. We presented 10 potential impacts of cellulosic ethanol production and asked Mainers to rate the importance of each; the levels of importance seemed to fall into three tiers (Table 6).

The highest tier of importance included increasing local employment and decreasing fuel imports; as seen earlier, local employment seems to be the primary driver of the latter impact. Mainers also placed changes to forest health in this highest tier of importance. In the middle tier, Mainers were concerned about how biofuel harvests may affect the prices of other wood fuels (primarily firewood and wood pellets) and harvest intensity. A study by Marciano et al. (2009) found that 13 percent of Mainers thought that current harvest levels were too high, while 42 percent were unsure. Decreasing global warming relative to gasoline was also in this middle tier. The lowest tier included lowering the trade deficit, decreasing global warming relative to corn-based ethanol, and declines in recreation opportunities in forests.

Cellulosic ethanol is touted as producing lower global-warming gases relative to other transportation fuels; however, Mainers found this to be a relatively unimportant benefit. In fact, interest in global-warming issues was consistently low throughout the survey, indicating that messages about cellulosic ethanol's ability to decrease global warming may be of interest to a limited audience. The ability of cellulosic ethanol production to increase local employment is much more important to Mainers. However, work by Marciano et al. (2009) indicates support for biorefineries declines as they approach an individual's community, suggesting that NIMBY-ism (not in my backyard) is likely to be an issue. Potential impacts on the forest environment are also highly important. Given the importance of forest impacts to Mainers, promoters of cellulosic ethanol should make sure harvesting practices are environmentally sound and sustainable, and that this is well communicated to the public.


TABLE 6: Importance of Benefits/Risks of Cellulosic Ethanol Production from Wood: Percentage of Respondents Indicating Benefit or Risk Is Somewhat to Very Important

Behaviors and Views	Maine	New England
	----- % -----	
Increases local employment	73	72
Decreases dependence on foreign fuels	72	76
Increases risks to wildlife	71	76
Promotes sustainable forestry	71	67
Increases the price of other wood-based fuels	62	50
Increases intensive logging	59	61
Decreases global warming relative to gasoline	58	66
Lowers the U.S. trade deficit	53	61
Decreases global warming relative to corn-based ethanol	48	54
Lowers forest recreational opportunities	46	54

CONCLUSIONS

This work provides empirical evidence that consumers do not hold identical (or even similar) knowledge base and preferences when it comes to a new energy technology, such as wood-based biofuel. We have found that consumers judge the value of biofuels by using their *a priori* knowledge of ethanol sources, their perceptions of the attributes of different fuels, and their interest in the ways that cellulosic ethanol might mitigate the impacts of fossil fuels. Interestingly, consumers in the Northeast focus more on the economic, environmental, and national security attributes of this type of fuel than on global warming and other environmental concerns.

At the current levels of ethanol blend in transportation fuels (i.e., E10) consumer choice may not be a driving factor of the market. However, as decision makers look ahead to higher fuel blends (i.e., E20 or greater) to meet RFS consumption standards, the importance of consumer preferences and attitudes towards ethanol is revealed; consumer attitudes about price, fuel performance, flex-fuel vehicles, and

environmental impacts will affect the volume and type of biofuels sold. As consumers become increasingly aware of the attributes associated with biofuels, and the differences between various biofuels, a window of opportunity may open for Maine. Mainers must carefully evaluate the tradeoffs associated with production and use of wood-based cellulosic ethanol. We hope this article contributes to this crucial conversation. 

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