

ABSTRACT

PIRES, STEVEN TYLER. Social Perceptions of the Biofuel Industry in the Southeastern US. (Under the direction of Dr. Sudipta Dasmohapatra).

The purpose of this study was to assess the perceptions of various stakeholders including consumers, forest landowners, universities, industry, government, and non-government organizations concerning energy and biofuels for transportation in the Southeast. Data were collected from the stakeholders using an electronic survey administered in summer 2010, resulting in 605 responses. Major components of the questionnaire included environmental awareness, perception of biofuels, and perceptions of alternative feedstocks for biofuel production including an emphasis on genetically modified (GM) trees and crops.

Results from this study indicate moderate support for biofuels among the sample of Southeastern residents indicated by 57.5% of respondents willing to purchase biofuel over gasoline. Respondents were most willing to purchase (WTP) biofuels produced from crop, wood, and landfill wastes (81%, 78.9%, and 75.3% of respondents, respectively). Respondents were least WTP biofuels produced from trees and GM trees, (57.3% and 50.4% of respondents, respectively). No statistically significant difference was found between the maximum price that respondents were willing to pay for a gallon of biofuels (\$3.37) and gasoline (\$3.32) at 95% significance ($p=0.444$). In addition, respondents indicated that they were looking for more information about biofuels in general and specifically, about its effect on their vehicle to make informed purchase decisions.

The forest landowner group has not been well represented in past studies about biofuels and bioenergy. The results of this study showed that forest landowners were most

willing to purchase biofuels from wood waste, landfill waste, followed by trees (95.1%, 93.0% and 88.4%, respectively). The forest landowner group also strongly supported procurement of wood for biofuel production if sustainable harvesting principles were utilized (for each tree cut another is replanted) (mean=4.07). In addition, this group of stakeholders did not support any government subsidy associated with biofuels production.

With regards to support of GM trees and crops (and its benefits and use for biofuel industry), the study found four distinct segments across the public. The first segment (35% sample size) is the “resource and economic concerned females,” consisting of females who supported GM for biofuels only if non-food feedstocks were utilized. The second segment (13% sample) was the “GM adverse environmentalists” consisting of non-government organization representatives who were environmentally conscious and indicated that GM is harmful and unethical. The third segment (18% sample), the “benefit driven GM supporters,” was mostly male and includes research, industry, government personnel and forest landowners. This segment supported GM trees and crops only if they saw some benefit associated with it. The fourth segment (34% sample), the “supply concerned consumers” that consists of 100% males who would like to see the supply of feedstocks increase and GM is seen as an alternative for doing that.

Results indicate a strong possibility of success in expanding the biofuel industry in the Southeast under a carefully devised marketing campaign. Promotional efforts from credible agencies (government and private) should include more information about biofuels in general and how it affects vehicles. The price of biofuels also needs to be consistent with that of gasoline for the consumers to purchase the biofuels. When considering GM-based

feedstocks for biofuels, each of the four segments need to be targeted with different promotional strategies based on their attitudes. Data from this study should be used to guide industry professionals and policymakers in making informed decisions about biofuels in the Southeastern US.

Social Perceptions of the Biofuel Industry in the Southeastern US

by
Steven Tyler Pires

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APPROVED BY:

Sudipta Dasmohapatra
Committee Chair

Toddi Steelman
Member of Advisory Committee

Robert Bruck
Member of Advisory Committee

DEDICATION

To my lovely mother who has always faith in me and my abilities no matter the situation. To my father who always pushed me to achieve the highest possible state of physical and mental attainment. To my brother for helping me find my true self and making me who I am today. To my family for providing me with continual support and guidance. To my amazing friends who have been there for me since day one— I could not be more grateful for all of you (you know who you are). I would not be who or where I am today without you all. Much love and respect.

BIOGRAPHY

Steven Tyler Pires was born to Mike and Hollice Pires September 21, 1985 in Foxborough, Massachusetts. The younger brother of Paul Pires, Steven lived in Foxborough until age six, when he moved to Weaverville, North Carolina. Weaverville, about 15 miles north of Asheville, is a small mountain town where Steven early acquired his love and appreciation for the natural environment. Steven joined the Cub Scouts at a young age and later ended his scouting career as a Life scout. This experience in scouting further solidified his fascination and dedication to the natural world. After graduating high school, Steven enrolled at Asheville-Buncombe Technical Community College (AB-Tech) to fulfill the general education course requirements of a four year bachelor degree. At AB-Tech Steven held the position of the Vice President of Student Government where he and other members implemented a campus wide recycling program. After receiving his Associate in Science, Steven applied to North Carolina State University and enrolled in the Environmental Technology (ET) curriculum. Early in his undergraduate studies in ET, he knew he had found his calling and opportunity to give back to the environment. He received his bachelor's degree in Environmental Technology, Summa Cum Laude, at North Carolina State University in May of 2009. After graduation, he spoke with Dr. Sudipta Dasmohapatra about graduate research opportunities in the Department of Forest Biomaterials; later signing on to her Bioproducts Group and pursuing his Masters of Science in Forest Biomaterials.

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TABLE OF CONTENTS

LIST OF TABLES	viii
LIST OF FIGURES	x
1. Introduction.....	1
2. Literature Review.....	3
2.1 Forest biomass, biofuels, and Southeastern opportunity	3
2.2 Previous work on biofuel perceptions.....	4
2.3 Social perceptions associated with genetic modifications of feedstocks.....	7
3. Materials and Methods.....	9
3.1 Stakeholder database.....	9
3.2 Instrument design.....	10
3.3 Data Collection	11
4. Social Perceptions of the Biofuel Industry in the Southeastern United States	1
4.1. Introduction.....	2
4.2. Social Perceptions of Bioenergy	4
4.3. Objectives	7
4.4. Materials and Methods.....	8
4.4.1 Instrument design.....	8
4.4.2 Stakeholder database.....	8
4.4.3 Data Collection	9
4.5. Results and Discussion	10
4.5.1 Demographic information.....	10

4.5.2 General perceptions of energy and the environment	11
4.5.2.1 Willingness to purchase biofuel.....	16
4.5.2.2 Social perceptions of biofuel	19
4.6. Conclusions.....	21
4.6.1 Limitations and future work.....	22
4.6.2 Acknowledgements.....	23
4.7. References.....	23
5. Biofuels and Wood-Based Feedstocks: A Study of Forest Landowner Perceptions	28
5.1. Bioenergy and Forest Landowners	29
5.2. Objectives	32
5.3. Methodology	33
5.3.1 Survey Instrument.....	33
5.3.2 Data Collection	33
5.4. Results and Discussions.....	33
5.4.1 Demographics	33
5.4.3 General Perceptions of Energy and the Environment.....	35
5.4.4 Perceptions of Genetically Modified crops/trees.....	37
5.5. Conclusion	41
5.6. Acknowledgments.....	42
5.7. References.....	43
6. Stakeholder perceptions of genetic modifications and its role in feedstock enhancement for biofuel production: A segmentation perspective	45

6.1. Introduction.....	46
6.1.1 Genetic Modification and Social Acceptance.....	47
6.2. Objectives	49
6.3. Methodology	49
6.3.1 Instrument design.....	49
6.3.2 Stakeholder database.....	50
6.3.3 Data Collection	50
6.4. Stakeholder perceptions of general environment and energy	51
6.5. Stakeholder perceptions of GM-based benefits and risks statements (including biofuels application)	53
6.6.1. Factor analysis results	56
6.6.2. Segmentation results	58
Segment 1—Resource and economic concerned females (Segment size=173, 35%)	61
Segment 2—GM adverse environmentalists (segment size=65, 13%).....	62
Segment 3—Tradeoff and benefit driven GM supporters (segment size=89, 18%).....	64
Segment 4—Male GM supporters for increased feedstock supply (Segment size=168, 34%).....	65
6.6. Conclusions.....	66
6.6.1 Policy implications.....	68
6.6.2 Future work.....	68
6.7. Literature Cited	68
7. References.....	71

LIST OF TABLES

Table 1. Summary table for number of email invitations sent to each stakeholder group and their respective response rates	10
Table 2. Mean and standard deviation of responses from environmental concern topics (1=not at all concerned to 5=very concerned)	12
Table 3. Mean and standard deviations of responses of environmental behavior topics (1=not at all concerned to 5=very concerned)	14
Table 4. Mean and standard deviations of responses from agreement statements considering biofuels (1=strongly disagree to 5=strongly agree)	20
Table 5. Demographic information of the forest landowners within our sample population .	34
Table 6. Respondents' general environmental concern (1= not at all concerned to 5=very concerned) (n=42).....	35
Table 7. Respondents' general perceptions of biofuels based on an agreement scale (1=strongly disagree to 5=strongly agree) (n=42)	36
Table 8. Respondents' general perceptions of the genetic modification with specific reference to biofuel production (n=42).....	39
Table 9. Survey completes (n=605) and response rate by stakeholder category	51
Table 10. Summary of responses towards environmental concern topics (1=not at all concerned to 5=very concerned).....	52
Table 11. Perceptions of genetic modifications in trees and crops (n=605).....	54
Table 12. Factor results in reference to perceptions of genetic modifications of feedstocks .	57
Table 13. Factor results in reference to respondent general environmental concerns	58

Table 14. Segmentation summary..... 60

LIST OF FIGURES

Figure 1. Forest biomass density in the continental US.....	4
Figure 2. Key components to product success in the rising bioeconomy.....	5
Figure 3. Respondent perceptions of energy sources based on their renewability and sustainability	15
Figure 4. Respondent willingness to purchase biofuels from various feedstocks	17
Figure 5. Map representing respondent residency at the time of questionnaire completion (map generated using Google Maps 2011)	34
Figure 6. Respondent perceptions of renewable/sustainable nature of energy sources (n=42)	37

1. Introduction

The expansion of the biofuel industry in the Southeastern United States has the ability to enhance economic development (Dwivedi & Alavalapati, 2009; English, De La Torre Ugarte, Walsh, Hellwinkel, & Menard, 2006; Mayfield, Foster, Smith, Gan, & Fox, 2007), promote energy security, and reduce the environmental impact of fuel consumption (English, et al., 2006). An increasing concern for the environment coupled with concerns of petroleum supplies have helped promote research about renewable transportation fuels, such as biofuel (Hill, Nelson, Tilman, Polasky, & Tiffany, 2006). With the promotion of government supported renewable energies, including biofuel, researchers have made huge advancements in ethanol fermentation, with 97% efficiency (Dale, 2008).

According to the US Energy Information Administration, 8% of the total United States energy consumption in 2009 came from renewable energy sources. Of these sources, 50% came from biomass derived energies (Guey-Lee, 2010). This widespread increase in use of biomass based fuels and energy sources is likely due to a projected scarcity of petroleum by 2010 (Kikuchi, Gerardo, & Santos, 2008). Kikuchi, et al. (2008) also point out that this scarcity will become exacerbated by a growing “global energy demand” projected to increase from 8.4 billion tons of oil equivalent (btoe) in 1995 to about 12.6 btoe by 2020, a mean yearly increase of 1.6%.

According to the US Census Bureau, the world population is 6.9 billion currently and is projected to exceed 9 billion by 2050 (Bureau, 2010b), putting intense pressure on energy and resources. This increase in demand for natural resources creates an even greater need to

pursue the development and production of renewable biofuels. The Energy Independence and Security Act of 2007 (EISA 2007) mandates the increase in production and use of cellulosic biofuels, non-cellulosic biofuels, and biodiesel over the next thirteen years; making the total production of all biofuels 36 billion gallons per year by 2022. Since biofuels are a liquid fuel, they provide a direct substitute for “either diesel or gasoline” and have the ability to be completely “renewable and carbon neutral” (Dale, 2008). This makes them the only petroleum substitute that can “provide potential large-scale economic, national security, and environmental advantages” (Dale, 2008). In 2008, more than 50% of the gasoline sold in the United States was a blend of 10% ethanol and 90% gasoline (Renewable Fuels, 2008).

Considering the increasing governmental push for biofuel production, it becomes necessary to better understand the associated social perceptions to make informed decisions in policy making and marketing of these products. This study aims to gauge the social perceptions about energy and biofuels for transportation. Integrating stakeholder perceptions in the decision making process is a critical step for the successful development of any policy (Dwivedi & Alavalapati, 2009). Thus, this study will measure the perceptions of several groups of stakeholders which are likely to have an impact in the acceptance of the biofuels in the marketplace.

The data obtained from this study will have profound implications for both policymakers and industry alike. Knowing how this sample Southeastern population perceives the concepts associated with expanding the biofuel industry will help highlight common misconceptions and gaps in education and will allow targeted promotion.

2. Literature Review

2.1 Forest biomass, biofuels, and Southeastern opportunity

With the increasing demand for biomass for biofuels and bioenergy (a 3% increase in biomass derived energies from 2004-2005, EIA 2010), largely as a result of government mandates and increasing scrutiny of environmental and national security concerns, questions arise from current bioproduct industries as to the feasibility of meeting this demand. To address these concerns, the US Department of Energy and the US Department of Agriculture released a study titled, “Biomass as feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply” which is commonly referred to as the “Billion ton study” (2005). The Billion Ton Study evaluates whether the land resources in the United States have the potential to supply enough biomass to accomplish a 30% reduction in our country’s present petroleum consumption, a goal set forth by the US DOE in 2003. To accomplish this 30% reduction using a variety of feedstocks, including all plant and plant derived materials, would require approximately 1 billion dry tons of biomass feedstock per year (Perlack et al., 2005). The Billion Ton Study also concludes, with minimal changes in land use, forestland and agricultural land have the potential to provide 1.3 billion dry tons of biomass per year. This presents an outstanding opportunity for the Southeastern US due to their high density of harvestable forest biomass. Figure 1 represents a US Forest Service forest biomass density map of the United States. Clearly, the Southeast will likely play a critical role in the harvesting, processing, and production of forest-derived biofuels.

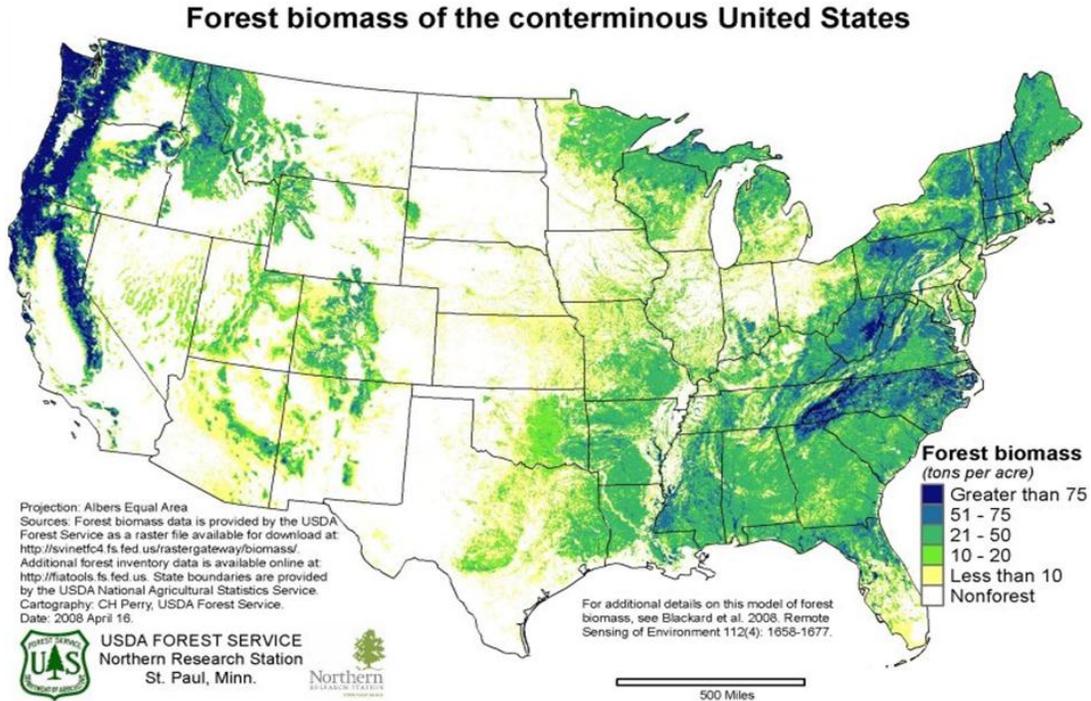


Figure 1. Forest biomass density in the continental US

2.2 Previous work on biofuel perceptions

Many researchers have indicated that public support for the bioenergy industry is critical for its ultimate acceptance in the marketplace (Dwivedi & Alavalapati, 2009; Morrone, Stuart, McHenry, & Buckley, 2009; Popp et al., 2009). However, the vast majority of the past and present research taking place in the biofuels and bioenergy industries focuses on the technical, economic, and ecological components. Figure 2 is a schematic depicting the four key elements for the success of new products in the rising bioeconomy. Lacking in any one area is likely to cause product failure.

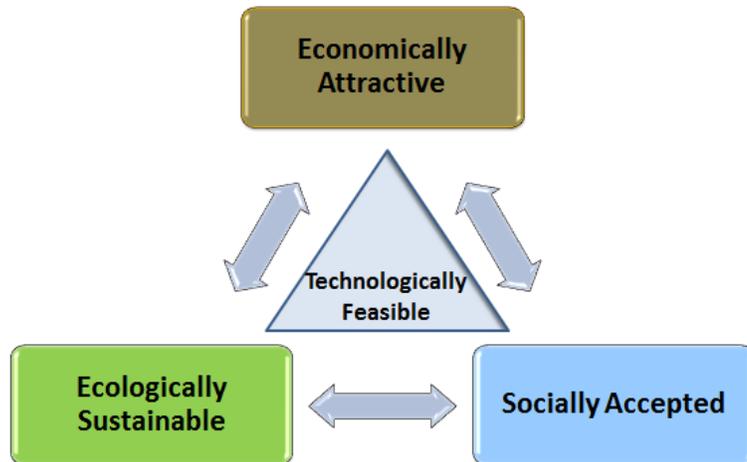


Figure 2. Key components to product success in the rising bioeconomy

Prior to launching our study, a review of the most current and relevant literature concerning the social acceptance of biofuels and bioenergy was conducted. Past research by Ulmer et al. (2004) suggested that cost was the most important factor associated with consumer purchase decisions of ethanol (Ulmer, Huhnke, Bellmer, & Dwayne Cartmell, 2004). The 2004 study by Ulmer et al., surveyed a small random sample of Oklahoma registered voters to assess consumers' knowledge and perception of biofuels. Their study yielded 685 respondents (37.6% response rate), which were all contacted using a mail surveying strategy. The results of this study concluded that consumers perceive the biofuels to be more expensive than gasoline (Ulmer, et al., 2004). Other key findings from the Ulmer, et al (2004) study were that many respondents were willing to purchase biofuels, respondents agreed that expanding the ethanol market in Oklahoma could positively affect the economy, biofuel had a perceived ability to reduce US dependency on foreign oil sources, and biofuel was thought to be more environmental friendly than gasoline.

Purchase decisions based on biofuels for transportation and fuel economy of new vehicles were researched in a study by Popp, et al., (2009). The study sought to compare the driving force behind a consumers' interest in fuel economy when purchasing a new vehicle. The focus of their research involved a number of topics including: importance of environmentally friendliness of fuel (production and use), importance of domestic fuel production, importance of reduced vehicle maintenance costs due to biofuel use, decision to prefer lower food prices versus higher fuel prices, and importance of required engine modifications to run vehicle on biofuels (Popp, et al., 2009). Sampling strategy included personally administering the surveys to fuel purchasing customers at two different fueling stations, a total of 2,710 respondents were surveyed. Results showed that consumers who felt strongly about their own ability to influence the environment placed high importance on fuel economy. Importance of domestically produced fuel had an unanticipated negative impact on the importance of fuel efficiency, perhaps due to the perception that domestic fuel consumption positively affected local economies.

A study by Dwivedi and Alavalapati (2009) conducted a SWOT (strength, weakness, opportunity, and threat) analysis on a targeted list of stakeholders (government, NGOs, industry, and academia) concerning forest-based bioenergy industry expansion in the Southern US. Contact information from experts in the bioenergy field was gathered through personal contacts, publications, government agencies with bioenergy focus, and internet search. Invitations to participate in the questionnaire were sent electronically, yielding 37 responses. Results indicate that all stakeholders were in favor of forest biomass-based bioenergy development in the Southern US (Dwivedi & Alavalapati, 2009). Dwivedi, et al.,

(2009) also point out that more information regarding forest landowner and consumer perceptions will be critical for effective policy formation.

Selfa et al., (2010) conducted surveys and focus groups of local communities in Iowa and Kansas (where ethanol plants were located) to better understand the community perceptions of the bioenergy industry in these regions. Random households were selected, paper survey invitations were sent, and one postcard reminder was sent two weeks after initial mailing. Results of this study showed that respondents (n=661) feel ethanol plants had only a modest economic benefit to the community (Selfa, Kulcsar, Bain, Goe, & Middendorf, 2010). Respondents revealed concern for the future viability of the industry and its impact on resource competition (e.g., water is sometimes scarce in these areas).

2.3 Social perceptions associated with genetic modifications of feedstocks

As populations increase, the level of demand for bioproducts and natural resources will also increase. To offset these increases in demand, intensive management of fast-growth softwood and hardwood plantations will be critical to both the bioproducts (Rousseau, Kaczmarek, & Martin, 2005) and biofuel industries. Using genetically modified (GM) technologies in feedstocks (to improve cell wall characteristics, yield and stress tolerance) is a key component of the US Department of Energy's long term strategy to meet the demands of increased production of biofuels (Chapotin & Wolt, 2007). Chapotin et al., (2007) also point out that the technological advancements for meeting these biomass demands are

available, but they rarely consider problems associated with the use of these GM crops such as regulatory approval, market adoption, and public acceptance.

Societal research concerning biotechnology and consumer acceptance have proven that many consumers do not outright reject genetic engineering, but are often skeptical of how and where these technologies will be applied (Blaine, Kamaldeen, & Powell, 2002). Blaine, et al., (2002) also point out that public objections to biotechnology typically stem from applications directly involving animals or humans. Biotechnology applications in many other situations tend to have greater public acceptance. The study by Blaine, et al., (2002) was an extensive literature search themed around the public perceptions of biotechnology. Findings were compiled from a variety of sources, including data from consumers in Australia, UK, Germany, France, Canada, and the US. After compiling data from these sources, a number of conclusions were made. It was found that media coverage has had a negative impact on the perception of biotechnology, increasing the amount of science and technology information available would promote acceptance, consumers are increasingly aware of the use of genetic modifications but understanding remains low, acceptance tends to be conditional and closely related to trust in regulatory agencies, and there is consensus concerning the need for increased government and industry interaction with the public concerning the biotechnology issues (Blaine, et al., 2002). In terms of marketing and research, this study is far too broad to make any well informed predictions about a much smaller regional population. Understanding the social perceptions of GM (specifically, in its application for bioenergy and other areas) will be valuable to illustrate gaps in understanding

thus, allowing for opportunities to bridge these gaps through education and informed policy making.

After reviewing the literature, the following gaps are evident: 1) stakeholder perceptions of biofuel in the Southeastern US is critical, 2) research is lacking in how forest landowners and consumers view the rising biofuel economy, 3) more research needs to take place concerning the social acceptance of biofuel feedstock modifications. Our research hopes to be relevant in both scope and target audience to assist Southeastern biofuel industries and policy makers in making informed decisions about the rising bioeconomy.

3. Materials and Methods

3.1 Stakeholder database

Stakeholder groups of interest included consumers, forest landowners, government, universities, industry, and non-government organizations. Research by Dwivedi and Alavalapati (2007) states the need for future research on public perception of biofuels to include more stakeholder categories, especially forest landowners and consumers. Our study addresses this gap in knowledge. Before data collection and survey instrument design, contact information of stakeholders were obtained and subsequently used as the sample population. Considering our reliance on an electronic survey medium, stakeholder emails were primarily obtained and in the following manner:

- *Consumers*: randomized consumer emails were purchased from a third party marketing firm

- *Forest Landowners*: an electronic link of our survey was generated for distribution in the Forest Landowner Associations list serve in their monthly membership update
- *Government*: contacts were obtained through search of public records and through project partner networks throughout the Southeast
- *Universities*: a random sample of researchers were selected from universities across the Southeast (collected from the web)
- *Industry*: contacts were generated from various bioenergy websites and conferences
- *Non-government*: contacts were obtained from public records on the web (including contacts from environmental non-profit entities)

During the process of compiling our stakeholder database we were simultaneously creating and refining our survey instrument.

3.2 Instrument design

Our study intended to highlight key gaps in public understanding of biofuels for transportation purposes. We also wanted to gain insight on how a variety of stakeholders view making biofuels from various feedstocks. The survey instrument consisted of multiple choice, open-ended, select all that apply, and 5 point likert scale opinion questions. The questionnaire consisted of 23 questions and was created using a third party online survey software package. The questionnaire started with basic demographic questions and transitioned into more focused questions relating to biofuel and perception. The questionnaire was divided into four main sections: 1) demographics, 2) general perceptions of the environment and renewable energies, 3) general perceptions of biofuel, and 4) general

perceptions of genetically engineered trees and crops. After going through many iterations of the survey, we generated a final draft for pilot testing. A random sample of 35 participants was selected for the pilot test. We asked each of these participants to time how long it took to complete the survey and document any confusion they had when answering each question. These suggestions and times were tabulated and shortly after we set up a meeting with our project sponsors to discuss modifications of certain questions and shortening the instrument to increase respondent retention. A final draft of the instrument was created and this was used in data collection and administered to each of our stakeholder groups separately.

3.3 Data Collection

Data collection took place from April, 2010 through August, 2010 and a total of 38,935 email invitations were sent. SurveyMonkey was the primary software package we used to manage our questionnaires. SurveyMonkey places no limit on the number of surveys you can create; to keep track of all responses we created duplicate surveys for each stakeholder category (e.g., duplicate surveys for consumers, forest landowners, NGOs, etc.) each containing a unique questionnaire link which allowed respondents to access the survey. This enabled us to assess each group separately and allowed for more in depth statistical analysis.

Unique questionnaire links were embedded within each email solicitation letter. We created different solicitation letters for each stakeholder categories in hopes of yielding the highest number of responses. The solicitation letters contained basic information for the motivation behind our study and instructions on how to participate (and opt-out of receiving

messages in the future). We also informed subjects that upon completion of our questionnaire, they would be entered in a raffle to win one of three iPods. The subject title of each of the emails was, “NC State University: Social Research for Energy & the Environment” in hopes of immediately gaining respondents trust of participating due to the use of NC State University in the title. A total of 38,935 email invitations were sent during the course of our study. Due to our methodology in acquiring consumer contacts (purchasing from a third party) we had difficulty sending emails to this stakeholder category. Difficulties in sending to this category included automated reply messages (when respondent is out of town), high number of emails being marked as SPAM, and high number of “bounced” emails (due to invalid email address). A bounce rate of 17.4% was calculated, indicating that the purchased list may have needed to be scrubbed for invalid addresses.

Due to this high bounce rate, after sending out the first invitations to our NC group, SurveyMonkey revoked our mailing privileges. To avoid this problem occurring with future invitation messages, Atomic Mail Sender v7.05 was purchased and used to manage the sending of all other messages. Atomic Mail Sender has the same capabilities as SurveyMonkey in sending mass email messages. Each stakeholder category was allowed 30 days to respond after the initial invitation was sent. After 15 days of the survey being open, a reminder message was sent to inform participants that there were only 15 days remaining to participate. After going through this process with each stakeholder category and state, all surveys were closed and the data was compiled. A total of 701 surveys were started, including completed and incomplete surveys. It is hypothesized that due to the technical nature of the questionnaire, 96 of these respondents answered some demographic information

and did not complete any other sections. These types of responses were deemed incomplete and were not used in any of our analyses. After removing incomplete responses, we had a total of 605 completed questionnaires. This gives us an 86.3% survey retention rate and a 2% total response rate. Investing more finances in a more diligently scrubbed consumer contact list could significantly increase the response rate. Also, the reliance of our study on an electronic survey is potentially biasing our results of the higher class structure due to this demographic of people more likely to have a computer and email address they check regularly.

4. Social Perceptions of the Biofuel Industry in the Southeastern United States¹

Steven Tyler Pires^a, stpires@ncsu.edu, **Sudipta Dasmohapatra**^a, sdasmoh@ncsu.edu, **Adam Costanza**^b, adam.costanza@forestbiotech.org, **Susan McCord**^b, susan.mccord@forestbiotech.org

^aNorth Carolina State University—Department of Forest Biomaterials, Campus Box 8005
Raleigh, NC 27695

^bInstitute of Forest Biotechnology, 140 Preston Executive Drive, Suite 100G Cary, NC 27513

Abstract

Biofuel production has the ability to be both ecologically sustainable and economically attractive. As a result, plans for expanding this industry in the Southeastern US are steadily increasing. An abundance of research about biofuel production focus on their technical components. While these areas of research are critical to the feasibility of the industry, social acceptance and use of biofuels are likely to affect the volume and ultimate success of this industry. The purpose of this study is to assess the perceptions of various stakeholder groups (consumers, forest landowners, government, non-government, industry professionals, and researchers) in the Southeastern US concerning energy and biofuels for transportation. Electronic survey data were collected from stakeholders in Spring/Summer of 2010 resulting

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in 605 responses. Results from our study indicate widespread support for biofuels among respondents (57.5% indicating they would purchase biofuel over gasoline). Respondents were most willing to purchase biofuels produced from crop, wood, and landfill wastes (with 81%, 78.9%, and 75.3% of respondents willing to purchase, respectively). Respondents were least willing to purchase biofuels produced from food items (soybeans, corn, and potatoes), trees, and genetically modified trees (with 68.6%, 67.3%, 62.9%, 57.3%, and 50.4% of respondents willing to purchase, respectively). Although support for biofuels is strong among our respondents, there are still large gaps in consumer understanding about the biofuel topic in general. Data from this study should be used to guide industry professionals and policymakers in making informed decisions about expanding the use and production of biofuels in the Southeastern US.

Keywords: biofuel, social perceptions, renewable energy

4.1. Introduction

The expansion of the biofuel industry in the Southeastern US has the ability to enhance economic development (Dwivedi & Alavalapati, 2009; English, et al., 2006; Mayfield, et al., 2007), promote energy security, and reduce the environmental impact of fuel consumption (English, et al., 2006). Increasing concerns for the environment coupled with trepidation about dwindling petroleum supplies have helped to facilitate the research of renewable transportation fuels, including biofuel (Hill, et al., 2006). With the promotion of government supported renewable energies, particularly in biofuels, researchers have made huge advancements in ethanol fermentation, with almost 97% efficiency (Dale, 2008).

According to the US Energy Information Administration, 8% of the total US energy consumption in 2009 came from renewable energy sources. About half of that 8% included biomass-sourced energy (Guey-Lee, 2010). This widespread increase in use of biomass based fuels and energy sources is likely due to a projected scarcity of petroleum by 2010 (Kikuchi, et al., 2008). Kikuchi et al. (2008) also point out that this scarcity will become exacerbated by a growing “global energy demand” projected to increase from 8.4 billion tons of oil equivalent (btoe) in 1995 to about 12.6 btoe by 2020, an average yearly increase of 1.6%.

The Energy Independence and Security Act of 2007 mandates the increase in production and use of cellulosic biofuels, non-cellulosic biofuels, and biodiesel over the next twelve years; making the total production of all biofuels 36 billion gallons per year by 2022. Since biofuels are a liquid fuel, they provide a direct substitute for “either diesel or gasoline” and have the ability to be completely “renewable and carbon neutral”, thus making biofuel the only petroleum substitute that can “provide potential large-scale economic, national security, and environmental advantages” (Dale, 2008). In 2008, more than 50% of the gasoline sold in the US was a blend of 10% ethanol and 90% gasoline (Renewable Fuels, 2008).

Increasing ethanol consumption in the US has generated many myths about biofuels. The most common myths leave many wondering if biofuels will positively or negatively impact the environment and if they truly have a net positive energy gain (Dale, 2008). The public often have trouble adapting to new technologies. It took many years for society to completely shift to the digital age of technology; which is now almost completely reliant on using computers, cell phones, PDAs, etc. for just about every task and manufacturing process

possible. Using biofuels as a new energy technology may also have a lag period associated with widespread acceptance. However consumers, academics, non-government organizations, forest landowners, and industry professionals are likely to shift towards the acceptance of these renewable fuels sooner rather than later for a number of reasons. First, the EISA 2007 mandates the increased use and production of these renewable technologies. Second, petrofuels are no longer cheap or abundant, thus requiring their efficient utilization. Third, even if petrofuels were cheap and abundant, increasing consumer environmental consciousness and industrial focus on sustainable products and services may lead to their increased use.

4.2. Social Perceptions of Bioenergy

With government support through tax credits (as seen below) there has been a surge of research in the area of biofuel conversion technologies, two of the most important are:

- Volumetric Ethanol Excise Tax Credit, 45-cent per gallon tax credit for ethanol-blended gasoline
- 2008 Farm Bill, \$1.01 credit for every gallon of cellulosic ethanol produced

However, there is a lack of research concerning the social perceptions of biofuels across a variety of stakeholder categories. Social acceptance of any technology can act as a major barrier for product success (Mallett, 2007; Wüstenhagen, Wolsink, & Bürer, 2007), and this is no exception for the bioenergy or biofuel industries (Roos, Graham, Hektor, & Rakos, 1999; Stidham & Simon-Brown, 2008). There are also conflicting ideas about whether biofuels are beneficial from an environmental or energy balance perspective (Berthiaume,

Bouchard, & Rosen, 2001; Dale, 2008; Hamelinck & Faaij, 2006; Pimentel, 2003; Wang et al., 1999).

Past research by Ulmer et al. (2004) suggests that perceived cost of biofuels is the most important factor associated with the ultimate success of biofuel distribution and expansion (Ulmer, et al., 2004). The study by Ulmer et al. (2004) surveyed a small random sample of Oklahoma registered voters to assess consumer knowledge and perception of biofuels. The results of this study concluded that consumers (n=685) were willing to purchase biofuels, however they perceive the biofuels to be more expensive than traditional fuels, which could be a major barrier in their purchase decisions. Unfortunately, this study is geographically limited in terms of its sampling.

Purchase decisions based on biofuels and fuel economy were researched in a study by Popp et al. (2009) . The study sought to compare the driving force behind a consumers' interest in fuel economy when purchasing a new vehicle. Results from 606 respondents at two fueling stations (Arkansas and Belgium) showed that consumers who felt strongly about their own ability to influence the environment placed a high importance on fuel economy. The production of domestically produced fuel caused consumers to place less importance on fuel economy, possibly due a perceived strengthening of national security and local economy (Popp, et al., 2009). This study also found that gender and level of education had no significance on the consumer perceived importance of fuel economy, making future marketing strategies based on demography difficult. The survey results are likely to be biased towards respondents who felt strongly about fuel economy from a financial or environmental perspective.

Another recent study by Brochers et al. (2007) considered whether consumers' willingness to pay differed by energy source (e.g. willing to pay more for bioenergy, solar, wind, or "generic green" energy). Results from this study suggest that consumers are typically willing to purchase green energy in general; albeit, some specific sources of green energy from utility companies were more desirable than others (Borchers, et al., 2007). Therefore, using the term "green energy" when promoting energy options to consumers would not be advisable; rather, specifying the renewable energy source being used would yield most effective results. This study indicated that individuals preferred solar and wind over any generic green energy source, with biomass and farm methane found to be the least preferred sources (Borchers, et al., 2007). This study is geographically limited to New Castle County, Delaware. The study points out some notable details concerning the need to properly market a renewable energy source but fails to address willingness to purchase/pay for biofuels.

Research by Dwivedi and Alavalapati (2007) focused on analyzing the perceptions of four stakeholder groups (government, non-government organizations, industry, and academia) in reference to developing and expanding the forest-derived bioenergy industry in the southern US. The 37 respondents in this study agreed that "rural development" was an important opportunity for the forest bioenergy industry in the south. "Less or no competition with food production" and "promotes energy security" were indicated by respondents as the greatest strength of the biofuel industry. Industry professionals identified "conversion technologies are still under trial" as a major weakness in the development of the biofuel industry; whereas, academic stakeholders felt that the "competition from other renewable

energy sources” was a major threat to this industry. Overall, this study found that all stakeholder groups had positive perceptions about the development of the forest bioenergy industry in the Southeastern US. The low number of respondents in this study limits the accuracy of drawing conclusions for broader populations. The researchers also state a need for future research on public perception of biofuels to include additional stakeholder categories, especially forest landowners and consumers.

Our study addresses some of the aforementioned limitations in understanding the social aspects of the biofuels and bioenergy industry by focusing on a wider sample population including consumers, forest landowners, and other stakeholder categories in the Southeastern US. The goal of this research is to highlight key gaps in public understanding of bioenergy and biofuels for transportation as well as their willingness to purchase. The results of this study will provide information to biofuel affiliated industries and developing targeted stakeholder marketing strategies for user acceptance. These results will also help decision-makers direct future energy policies.

4.3. Objectives

The objective of this research is to assess the perceptions of a targeted group of stakeholders in the Southeastern US (including AL, AR, FL, GA, KY, LA, MS, MO, NC, SC, TN, VA, and WV) about energy, the environment, and biofuels. The specific objectives of this research are as follows:

- To examine stakeholder attitudes and behaviors toward energy and the environment in general;

- To understand their perceptions of biofuels for transportation and assess stakeholder willingness to purchase biofuels.

The stakeholder categories included consumers, forest landowners, government, non-government, industry professionals, and researchers.

4.4. Materials and Methods

4.4.1 Instrument design

An electronic survey instrument was designed consisting of multiple choice, open-ended, and 5 point likert scale opinion questions. All answer options to multiple choice and likert scale questions were randomized to avoid any bias in response. The questionnaire consisted of 23 questions and was divided into three main sections: 1) demographics, 2) general perceptions of the environment and renewable energies, and 3) general perceptions of biofuel and willingness to purchase. A random sample of 35 participants was selected for the pilot test from the stakeholder categories. We asked each of these participants to time how long it took to complete the survey and document any confusion they had when answering each question. The survey was modified in terms of length, wording, and language.

4.4.2 Stakeholder database

A database for each of the stakeholder categories (as indicated above) for data collection was generated using the following strategy:

- ✓ *Consumers*: randomized consumer emails from an electronic consumer database were purchased from a third party marketing firm
- ✓ *Forest Landowners*: an electronic link of the survey was generated for distribution in the Forest Landowner Associations list serve in their monthly membership update
- ✓ *Government*: contacts were obtained through search of public records and through project partner networks throughout the Southeast
- ✓ *Universities*: random sample of researchers were selected from universities across the Southeast (collected from the web)
- ✓ *Industry*: contacts were generated from various bioenergy websites and conferences
- ✓ *Non-government*: contacts were obtained from public records from the web (including contacts from environmental non-profit entities)

4.4.3 Data Collection

Data for this study were collected from April 1, 2010 through July 31, 2010 and a total of 38,935 email invitations were sent (Table 1). Each stakeholder category had 30 days to respond after the initial invitation was sent. After two weeks, a reminder message was sent to participants to encourage participation. At the end of the data collection period, 605 completed questionnaires were obtained. This approach yielded a 2.0% total response rate. Between 21%-32% response rates were obtained from the government, non-government, and industry contacts, whereas consumer and forest landowner groups had much lower response rates. It should be noted that the forest landowner contacts did not receive a direct email similar to other stakeholder groups, which may have contributed to a low response rate for

that group. Random sample e-mail surveys are likely to be ignored by respondents (Klassen & Jacobs, 2001), which may explain the lower response rates in the consumer category. A summary of invitation and response rate data can be found in Table 1.

Table 1. Summary table for number of email invitations sent to each stakeholder group and their respective response rates

Stakeholder Category	# of Invites Sent	Total # of Responses	Response Rate
Consumers	34,811	431	1.2%
Forest Land Owners	3,620	43	1.2%
Government	57	12	21.1%
University/Industry	258	58	22.5%
Non-government	189	61	32.3%

4.5. Results and Discussion

4.5.1 Demographic information

Of the respondents (n=605), 44% were females and 56% were males. When comparing this to the Southeastern US Census Bureau estimates for 2008 (51% females and 49% males) our sample over represented the male population. Since the purchasing decisions of children under the age of 18 are normally controlled by the parents, they were not considered in our study. About 85% of respondents in this study were White/Caucasian and 9% African American compared to 74% White/Caucasian and 20% African American in the Southeastern US according to the US Census estimates for 2008 (Bureau, 2010a). Of the respondents, 35% had annual income of \$75,000 or higher when compared to the 28% of the Southeastern US earning \$75,000 or greater in 2008. Considering education, 65% of

respondents had a 4 year College Degree (BA or BS) or higher. This is much higher than the 2008 US Census for Southeastern US, with only 23% of the population having a 4 year College Degree (BA or BS) or higher. This large discrepancy in our sample populations' demographic information (on all factors) is most likely due to the electronic mode of data collection. Using an electronic questionnaire and sending invitations to those with valid email addresses is likely to select higher income respondents (Solomon, 2001). This over representation of demographics is likely to bias our results; future work should include more diverse samples.

4.5.2 General perceptions of energy and the environment

The first section of the questionnaire was designed to evaluate the respondents' general environmental concern. Respondents were asked to evaluate their level of concern on several environmental statements on a likert scale where 1=not at all concerned and 5=very concerned. Results indicated that respondents were most concerned about US dependence on foreign oil (mean=4.5) followed by resource availability for future generations (mean=4.3) and pollutants in the environment (mean=4.3). Closely following these was price. The price of energy (e.g., electricity, natural gas, etc.) (mean=4.2) and price of transportation fuels (mean=4.2) were rated the 4th and 5th important statements. Table 2 shows the means and the spread of the data for each question statement. The results indicated that respondents placed high value on reducing US dependence on foreign sources of oil, the price of energy, and the price of transportation fuels.

Table 2. Mean and standard deviation of responses from environmental concern topics (1=not at all concerned to 5=very concerned)

Concern Topics	Mean	Standard Deviation
US dependence on foreign oil	4.5	0.8
Resource availability for future generations	4.3	0.9
Pollutants in the environment	4.3	0.9
The price of energy (e.g., electricity, natural gas, etc.)	4.2	0.9
Price of transportation fuels	4.2	0.9
Increasing global population	3.9	1.1
How much energy you are using	3.8	1.0
Endangered species	3.8	1.2
Greenhouse gas emissions	3.8	1.2
Global climate change	3.7	1.3
Food availability/shortage	3.7	1.2
Drilling more gas and oil wells in the US	3.6	1.3

Many past marketing studies have shown a difference in perception and behavior (Bamberg, Kühnel, & Schmidt, 1999; Clarke, Harvey, & Kane, 2000; Kaiser, Byrka, & Hartig, 2010; Wicker, 1971); thus, environmental behavior questions were asked to evaluate respondents' current environmental behavior. Respondents were asked to indicate how often they have participated in a variety of environmental actions in the past 12 months on a likert scale where 1=never and 5=very often (Table 3). Top five environmental actions were as follows: 1) turned off electronics when not in use ($\bar{x}=4.4$, $s=0.8$); 2) recycled or used recycled

products ($\bar{x}=4.2$, $s=1.0$); 3) purchased energy efficient light bulbs ($\bar{x}=4.1$, $s=1.1$); 4) purchased local products ($\bar{x}=4.0$, $s=0.9$); 5) removed myself from a mailing list (to eliminate junk mail) ($\bar{x}=3.6$, $s=1.3$). Table 3 shows the means and the spread of the data for these statements. These results seem to indicate that people partake in environmental actions when it is convenient or when it saves them money. This is especially important to note during marketing of environmental products (including biofuels) to consumers. Turning off electronics when not in use can be viewed as either an environmentally conscious action or an economically conscious action since both can save natural resources (coal, natural gas, etc) which in return save money. Recycling is a widespread idea, that which has become common practice in most households due to increased local government support making it easy and the norm.

Table 3. Mean and standard deviations of responses of environmental behavior topics (1=not at all concerned to 5=very concerned)

Environmental Behavior Topics	Mean	Standard Deviation
Turned off electronics when not in use	4.4	0.8
Recycled or used recycled products (made with recycled packaging)	4.2	1.0
Purchased energy efficient light bulbs as opposed to conventional light bulbs	4.1	1.1
Purchased local products	4.0	0.9
Removed myself from a mailing list (i.e., to eliminate junk mail)	3.6	1.3
Purchased or used biodegradable cleaning products	3.4	1.2
Purchased Energy Star appliances	3.4	1.3
Purchased food or beauty products with organic ingredients	3.2	1.2
Grown my own food	2.7	1.4
Volunteered/donated to an environmental cause	2.7	1.3
Used biofuels/biodiesel (as a transportation fuel)	1.6	1.1
Driven a hybrid vehicle	1.4	1.0

Respondents were asked to analyze a list of sources of energy in terms of their renewability or sustainability. This list of energy sources was based on the U.S Department of energy’s website under their Energy Sources section (Energy, 2009). For each of these energy sources, the DOE also distinguishes whether that particular source of energy is renewable or not. Solar, wind, hydroelectricity, geothermal, tidal, biofuel, and hydrogen energy sources are renewable according to the US Department of Energy. Results from each particular energy source and respondent perceptions are shown in Figure 1. Solar energy is

perceived to be the most renewable/sustainable source of energy by respondents (91.4% of respondents selected this source of energy to be renewable or sustainable). Wind energy was perceived as the second most renewable/sustainable source of energy (89.8%). Biofuel was perceived as the sixth most renewable/sustainable source of energy (60.03%), only scoring higher than one other renewable on the list (hydrogen, 50.4%).

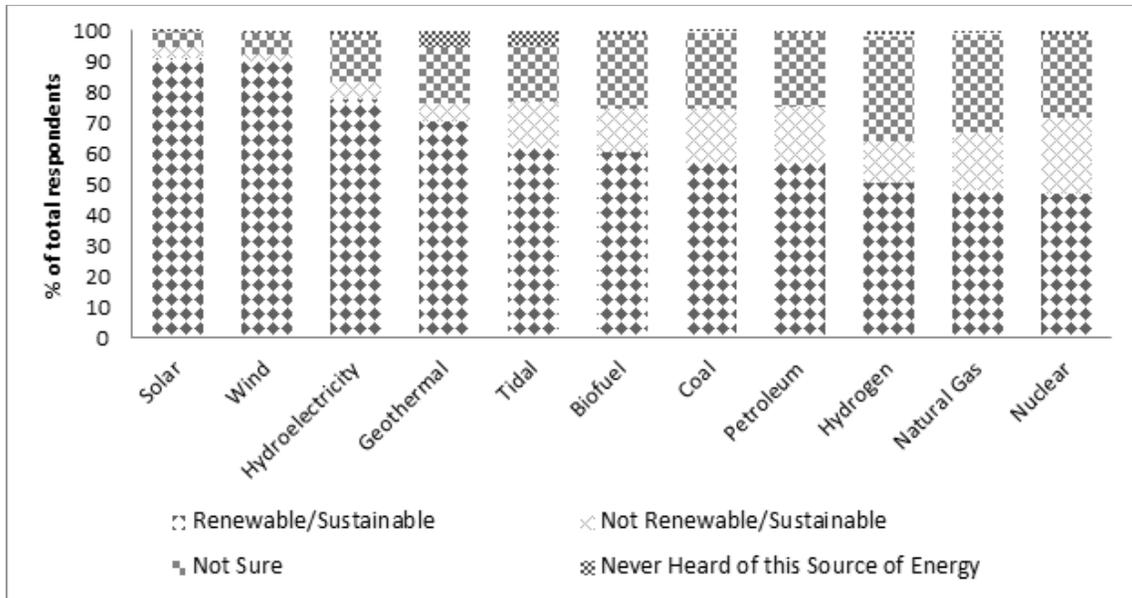


Figure 3. Respondent perceptions of energy sources based on their renewability and sustainability

Question statement: Which of the following sources of energy would you consider to be renewable/sustainable?

A study by the National Environmental Education and Training Foundation (NEETF) in 2002 found that only 12% of Americans could pass a basic quiz on energy knowledge. Topics on the NEETF survey included how energy is generated in the US, if average gas mileage is increasing or decreasing, and what the fastest growing sector in the energy markets, etc. Our study shows that even eight years later most Americans still have trouble making broader connections between energy use and production. This fact is clearly displayed by high numbers of respondents choosing “renewable/sustainable” for sources of

energy which are the non-renewable. The two most obvious examples of non-renewable energies on our questionnaire were coal (57.2% chose “renewable/sustainable”) and petroleum (56.8% chose “renewable/sustainable”). Other studies by NEETF also show that the vast majority of Americans (80%) base their environmental conclusions and stances on false or archaic environmental myths (Coyle, 2005) which could be a byproduct of low exposure to environmental concepts in an early educational setting. Despite much effort by NEETF and other environmental education foundations, environmental science has yet to reach “core” curriculum status due to increased focus on “education standards and related testing” (Coyle, 2005). Educating the nation by integrating these topics into required curriculum should be a key goal to solving obvious education gaps, such as the one highlighted above (renewability/sustainability of various energy sources).

4.5.2.1 Willingness to purchase biofuel

To capture consumer perceptions of what it would be like to have many choices at a gas station, respondents were asked to indicate their willingness to purchase biofuels sourced from different feedstocks (assuming that biofuel was available from these sources). On a willingness to purchase focus, all waste materials were ranked most desirable for purchase (crop, wood, and landfill waste with 81%, 78.9%, and 75.3% of respondents willing to purchase, respectively) when compared to other sources. Consumers have a negative perception of using food for biofuels possibly due to the food versus fuel debate; this is highlighted by the willingness to purchase responses to this question, with food based feedstocks at the bottom of the list. The only material less desirable than using food sources

(e.g., soybeans, corn, potatoes) for biofuel is using trees or genetically modified (GM) trees for biofuels (57.3% and 50.4% willing to purchase, respectively). The poor perception of using trees (or GM trees) for biofuels could be a result of a lack of knowledge surrounding cellulosic biofuels, uncertainty associated with GM crops, or due to the high aesthetic value of forested landscapes. A summary of results can be seen in Figure 2.

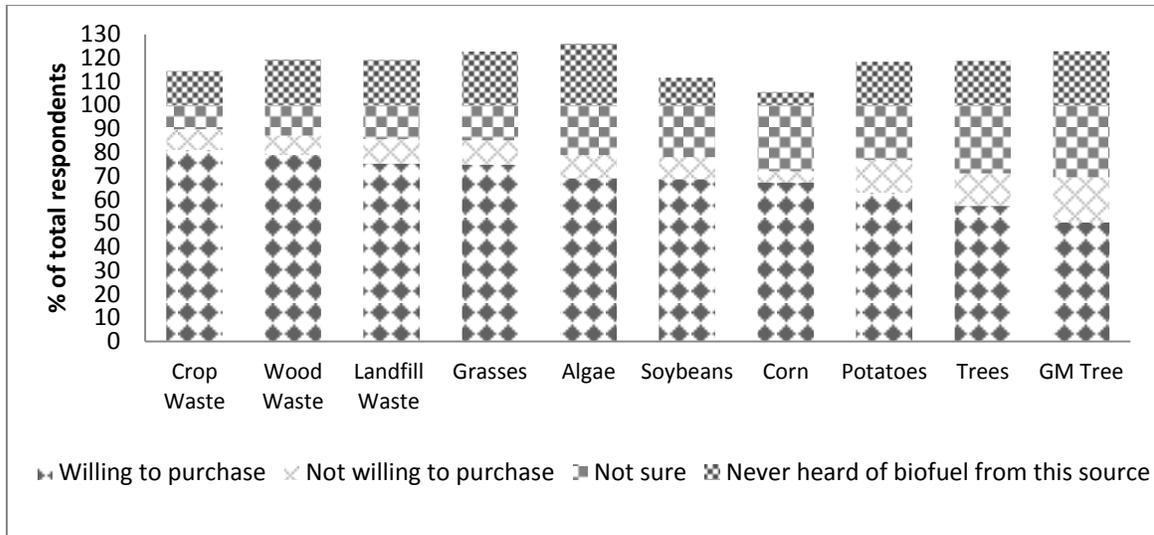


Figure 4. Respondent willingness to purchase biofuels from various feedstocks

Note: totals may exceed 100% due to mutually inclusive question categories

When asked about how much more respondents were willing to pay for biofuel versus gasoline, 37.7% said they would pay “the same price as gasoline/diesel.” Conversely, 62.3% of our respondents reported they would be willing to purchase biofuel even if it were more expensive than gasoline. Our results correspond with data from previous studies. A study in Texas assessed how much respondents’ would be willing to pay for “green power and energy efficiency” and found that 50% of participants stated they would invest at least one dollar a month to support renewable energies and energy efficiencies (Zarnikau, 2003). However, it is important to note that there is often a large differential between what survey

respondents say they would be willing to do versus what their actual actions show (Bird, Cardinal, & National Renewable Energy, 2004). This study and the Zarnikau (2003) study both show consumers' willingness to pay more for renewable energy sources; albeit, existing renewable energy programs show weak signs of participation with a median participation rate of only 1% (Bird, et al., 2004). This needs to be taken into consideration especially when dealing with a commodity product such as gasoline or biofuel. To overcome these issues, strategic pricing strategies and marketing campaigns must be implemented. Focusing on the positive benefits of biofuel related to reducing the US dependence on foreign oil and conserving natural resources for future generations may likely have a profound positive impact on the perception of the Southeastern consumer.

When looking at the maximum price respondents' would be willing to pay for a gallon of gasoline and biofuel the results actually contradict the earlier discussion (where many respondents indicated they would be willing to pay more for biofuel). This corresponds to the Zarnikau (2003) study, where consumers state they would be willing to pay more for renewables; although, this is not truly reflected in actual participation in renewable energy programs that require price premiums. Respondents indicated to be willing to pay a maximum price of \$3.31 and \$3.36 for gasoline and biofuel, respectively. Although there a slight price difference, no significant statistical difference was found between the two specified prices (significance, $p=0.44$, $\alpha=0.05$).

These results are compelling from a marketing perspective. The main focus of marketing revolves around the idea of creatively conveying the resources (products or services) of a company in a way which is receptive and desirable to the consumer through

what is known as the “marketing mix” (Ring, Newton, Borden, & Biggadike, 1984). Ring et al. (1984) describes the “marketing mix” as a set of controlled variables a company uses to influence their target market in hopes of making a sale. In the marketing world, there are four key facets to this mix known as the “4 Ps” of marketing: product, price, place, and promotion (McCarthy & Perreault, 1990). Slight differences in similar products (fuels made from renewable materials or non-renewable materials, in reference to biofuel), how and where they can be purchased, the price, and choice of advertising strategy come as a “result of different marketing mix decisions” (Ring, et al., 1984). In terms of biofuel, the product directly competes with existing petroleum fuels. Biofuels boast energy security, environmental benefits, and provide a direct substitute for traditional petroleum based fuels. The price of biofuels should remain competitive with petroleum fuels, if not cheaper. Future technical development in this area must focus on economically attractive practices. In terms of place, new distribution channels may need to be established to make biofuels more widely available at all fueling stations. The promotion of biofuels will play a critical role in the success of expanding the industry. Promoting that a biofuel was sourced from “waste” materials may prove beneficial in improving consumer perceptions about this product.

4.5.2.2 Social perceptions of biofuel

A variety of statements were used to capture respondent perception of several biofuel topics. Both positive and negative statements concerning biofuels were created to avoid polarity of question types in one direction. A summary of agreement statements can be found in Table 4. On average, it appears that respondents question the biofuel topic and desire more

information about biofuels (in general) and how they would affect their vehicles (specifically). Respondents' also seem slightly unsure of biofuels (and biodiesel) and their ability to positively affect the environment. Mean value of agreement for the statement, "biofuels have a lower environmental impact than gasoline" is 3.5. This is only slightly above the neutral threshold of 3.0 and opens an opportunity for education to correct some common misconceptions and confusions surrounding biofuels.

Table 4. Mean and standard deviations of responses from agreement statements considering biofuels (1=strongly disagree to 5=strongly agree)

Biofuel Topics	Mean	Standard Deviation
Before I would purchase biofuels, I would like more information about how they would affect my vehicle	4.0	1.0
Some types of biofuel are better for the environment than others	3.8	0.9
I would like the government to provide me with more information about biofuels	3.6	1.1
Biofuels have a lower environmental impact than gasoline	3.5	1.0
Biodiesel has a lower environmental impact than gasoline	3.5	0.9
I would support the cutting trees for biofuels if for each tree cut another was replanted	3.4	1.3
I would purchase biofuels even if it is a little more expensive than gasoline	3.3	1.2
I would only purchase biofuels if they were available at most or all gas stations	3.2	1.1
I think the government should subsidize the manufacturing of biofuels	3.2	1.3
I would only purchase biofuels if they were the same price as gasoline	3.0	1.2
Every gallon of gasoline purchased in the United States is blended with ethanol	3.0	1.1
Biofuels are not environmentally friendly (they take more energy to make than it is worth)	2.8	1.0
I would not purchase biofuels because they might be bad for my car engine	2.6	1.0

4.6. Conclusions

This study assesses the public's perception of biofuels as a transportation fuel and shows positive signs for the biofuel industry. Various stakeholders are generally willing to purchase biofuels for transportation if the cost is comparable to that of gasoline. There is no significant difference in the maximum price respondents are willing to pay for biofuel versus gasoline. The data indicates widespread support for biofuels amongst our sample of Southeastern US residents (57.5% respondents indicating they would purchase biofuel over gasoline). Respondents were most willing to purchase biofuels produced from crop, wood, and landfill wastes (with 81%, 78.9%, and 75.3% of respondents willing to purchase, respectively). Thus, it may be advantageous for Southeastern biofuel producers to engage in push marketing campaigns advertising the fuels production focusing on the use of waste materials. Respondents were least willing to purchase biofuels produced from food items (soybeans, corn, and potatoes), trees, and genetically modified trees (with 68.6%, 67.3%, 62.9%, 57.3%, and 50.4% of respondents willing to purchase, respectively). Only 60.3% of our respondents viewed biofuel as a "renewable/sustainable" product and 23.8% were "not sure" when asked to respond to the renewability or sustainability of biofuels. Respondents seemed confused by the concept of renewability or sustainability when considering energy sources in general. There is much room for education concerning this topic, which is further reinforced by high percentages of respondents choosing "renewable/sustainable" for energy sources that were not renewable.

Results from this study also suggest that future marketing strategies for the biofuel industry should focus on reducing US dependence on foreign oil, pricing the biofuels competitively, and making them widely available to the public. To increase acceptance and maintaining an accurate pool of knowledge and information, educational efforts must be implemented to reduce some misconceptions surrounding biofuels (e.g., their renewability and effects on car engines). Meeting the requirements of EISA (2007) and the Renewable Fuels Standard (RFS2) will not come easy. It will require careful management and marketing in a collaborative effort with government, non-government organizations, forest landowners, universities, industry, and consumer groups.

4.6.1 Limitations and future work

The reliance our study had on an electronic surveying strategy potentially biases the results to the higher education and income categories. This demographic of people is more likely to have a computer and an email address that they check regularly (Solomon, 2001). A larger scale study with more representative consumer groups may be required to confirm the findings and apply them to a national population. Future research in this area should allow more flexibility in the mode of data collection. Paper and electronic copies of the questionnaire invitations should be sent to each contact. This will help widen gaps in the demographic profile and increase response rates. Similar studies should also be implemented across all of the regions of the US (Midwest, Northwest, Southwest, Northeast, etc.) to compare stakeholder opinions throughout the nation. Including more responses from forest landowners and government contacts would also be beneficial because they are likely to play

a critical role in the future biofuel industry. Understanding how forest landowners perceive forest derived biofuels will be beneficial to successfully acquire biomass in the future.

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5. Biofuels and Wood-Based Feedstocks: A Study of Forest Landowner Perceptions²

Steven Tyler Pires^a, stpires@ncsu.edu, **Sudipta Dasmohapatra**^a, sdasmoh@ncsu.edu, **Adam Costanza**^b, adam.costanza@forestbiotech.org, **Susan McCord**^b, susan.mccord@forestbiotech.org

^aNorth Carolina State University—Department of Forest Biomaterials, Campus Box 8005
Raleigh, NC 27695

^bInstitute of Forest Biotechnology, 140 Preston Executive Drive, Suite 100G Cary, NC 27513

Abstract

Forest landowners are one of the key stakeholders in the rising biofuels economy, especially with the focus on cellulosic biofuels derived from woody biomass. This paper focuses on exploring forest landowner perceptions and concerns about the expanding biofuels industry while analyzing and comparing their perceptions of the possibility of using various feedstocks (including trees and GM trees) for biofuel production. An electronic survey link sent to forest landowners through the Forest Landowner Association's newsletter elicited 42 responses in summer of 2010.

Respondent forest landowners indicate a high degree of concern about the US dependence on foreign oil as well as uncertain resource availability for future generations. This is particularly evident when the respondents are willing to tradeoff the use of Genetically

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Modified (GM) trees and crops for US energy independence. Forest landowners indicate that they would support cutting of trees for biofuel production as long as a sustainable approach was taken (for each tree cut another was replanted). On average, forest landowner respondents were unsupportive of government subsidy for the manufacturing of biofuels; however, there were high variations in response to this statement. With respect to the renewable/sustainable nature of various sources of energy, the forest landowners considered biofuels in the middle (just better than nuclear, hydrogen, natural gas, coal and petroleum, in that order). The sources that were rated as highest were solar, wind, hydroelectricity, geothermal and tidal (in descending order).

GM applications of trees and crops for biofuel production was supported by the landowners if it reduced overall environmental impact and foreign oil dependence. GM was also supported in general, if used for species restoration. The results of this study provide an initial indication and direction of the forest landowner's understanding, motivation, and interest in the bioenergy industry. This information could also be used to guide policy decisions related to feedstock subsidies and a sustainable bioenergy industry in the Southeast US.

5.1. Bioenergy and Forest Landowners

Forests and woody biomass have gained much attention as a key feedstock used for biofuel production. Wood-based cellulosic ethanol is considered to be a sustainable way to reduce the consumption of fossil fuels (Caputo, 2009; Taylor, Lippke, & Park, 2010). However, the cellulosic biofuel industry will require the involvement and support from the

forest landowners in the US to be a success. Forest landowners may incur additional value and benefits from the extended market of wood energy from their forest biomass (Hillring, 2003). These landowners may be required to make decisions about investment in growth, production, management, and harvesting of their resources, especially for short rotation woody crops. To motivate the forest landowners, the government provides incentives including tax credits for energy based investments and loan guarantees to non-industrial forest landowners and farmers for their participation in the production of cellulosic biofuels (Rep Peterson, 2008). In addition, the Energy Independence and Security Act of 2007 provides criteria for potential Renewable Electricity Standards; including federal mandates requiring states to prepare biomass utilization assessments and landowners to file certified management plans for biomass destined to energy producing facilities.

Many past studies on understanding perceptions of various stakeholder groups about biofuels have failed to consider the forest landowner group.(Dwivedi & Alavalapati, 2009) indicate that including this particular group will be highly important in providing a complete picture of the societal understanding and assessment of the industry. The wood-based bioenergy market will be viable under the assumption that forest landowners are willing to devote their stands to energy markets and that current technology advancements prove to be economically attractive towards pushing landowners in that direction. These landowner decisions could play a big role in the future of the wood based bioenergy industry; thus, social research on this area is of paramount importance.

A comprehensive study on biofuels and biomass in Oregon evaluated social barriers by interviewing a small number of forest biomass utilization professionals (n=23) including industrial private and non-industrial private landowners, forest industry professionals, and pulp and paper industry professionals. The data were analyzed in aggregate and the stakeholders reported their need for an integrated bioenergy system that may handle a variety of feedstocks (wood, bark, and foliage) and an economically attractive utilization for logging slash (Williamson, 2007). The percent of forest landowners included in the study was too small to make any significant inferences about this group.

Another study by Conrad et al., (2010) surveyed 163 members of the forest products industry (landowners, mill owners, foresters, and loggers) about their perceptions of a rising wood-based bioenergy industry in the Southeast. The vast majority of respondents stated their willingness to sell their wood-based feedstocks to energy facilities (98% of respondents). These respondents also believed that this additional demand from the bioenergy industry would not limit current timber markets, but rather provide additional market opportunities to foresters and forest landowners (89%). Although the above results present an overwhelming positive leaning towards the bioenergy industry, the findings need to be confirmed for the forest landowner group only.

With the decline in the demand from traditional forest products markets due to a slipping housing market and depressed economy, opportunity exists in devoting forest feedstocks to meet the needs of the growing bioenergy industry. Past research shows that for many regions in the US, forest landowners reported an information and understanding gap

about the industry which has been a limiting factor in the development of local woody biomass and bioenergy markets (Grebner, Perez-Verdin, Henderson, & Londo, 2009). Provided key information gaps are filled, there is enormous potential for forest landowners to embrace biofuel industry investments leading to rural economic development.

Additionally, many forest landowners are not aware of the new bioenergy market and their ability to provide additional sources of income for materials which were once considered waste (wood waste) (Grebner, et al., 2009). Information regarding wood waste utilization must be effectively conveyed to the landowners in order to supply additional biomass to the biofuel industry. The focus on woody-biomass for bioenergy applications is having an increased interest on GM trees and crops (Sedjo, 2011). The Institute of Forest Biotechnology (2010) report that the next decade will experience a rapid expansion of biotech trees globally for biofuels and other applications. Thus, it is important to examine how landowners assess the risks and benefits of GM in their applications toward meeting biofuel demand.

5.2. Objectives

The objective of this study was to explore forest landowner perceptions about biofuels and the woody biomass (including GM trees) as feedstock for biofuels for transportation. Specific objectives of this study are as follows:

1. To explore forest landowner perceptions of the energy and the environment in general;

2. To understand their perceptions and gaps in understanding about biofuels and feedstocks for biofuels.

5.3. Methodology

5.3.1 Survey Instrument

An electronic survey instrument was designed consisting of multiple choice, open-ended, and 5 point likert scale opinion questions. All answer options to multiple choice and likert scale questions were randomized to avoid any bias in response.

5.3.2 Data Collection

Responses from the forest landowners were collected by using an electronic survey link in the Forest Landowner Association's monthly membership update in the April 14, 2010 issue. The landowners were encouraged to voluntarily participate in the survey and at the end of August 2010, 42 completed responses were received. The forest landowner contacts did not receive a direct email or any reminders that are commonly used in social surveys (which may have resulted in low response).

5.4. Results and Discussions

5.4.1 Demographics

The majority of the 42 landowner respondents in this study were residents of the Southeast. The geographic focus of our study was intended to be the Southeastern US,

although some respondents lie outside this boundary (Figure 3). Majority of the landowner respondents were males (83.7%) and over 55 years of age (67%). These forest landowners were well educated, with 93% of the respondents having a 4 Year College Degree and higher. A summary of the demographic information is shown in Table 5.



Figure 5. Map representing respondent residency at the time of questionnaire completion (map generated using Google Maps 2011)

Table 5. Demographic information of the forest landowners within our sample population

Age (yrs.)		Gender		Education	
25-34	9.3%	Male	83.7%	Some College	2.3%
35-44	9.3%	Female	16.3%	2 Year College Degree (Associate)	4.7%
45-54	14.0%			4 Year College Degree (BA or BS)	48.8%
55-64	39.5%			Graduate or Doctorial Degree	32.6%
65 +	27.9%			Professional Degree (MD or JD)	11.6%

5.4.3 General Perceptions of Energy and the Environment

Forest landowners were asked to evaluate their level of concern on several environmental and energy-based statements (on a likert scale, 1=not at all concerned to 5=very concerned). Respondents indicated a strong concern to reduce US dependence on foreign sources of oil (mean=4.63) and ensure resource availability for future generations (mean=4.14) (Table 6). Price related questions followed next, with the price of energy (mean=4.09) and the price of transportation fuels (mean=4.05) receiving high levels of concern.

Table 6. Respondents' general environmental concern (1= not at all concerned to 5=very concerned) (n=42)

Environmental Concern Topics	Mean	Std. Deviation
US Dependence on Foreign Oil	4.63	0.58
Resource Availability for the Future Generations	4.14	1.00
The Price of Energy (e.g., Electricity, Natural Gas, etc.)	4.09	0.72
Price of Transportation Fuels	4.05	0.79
Increasing Global Population	3.86	1.10
Pollutants in the Environment	3.67	1.06
How much Energy you are Using	3.47	0.88
Food Availability/ Shortage	3.21	1.01
Drilling More Gas and Oil Wells in the US	3.19	1.61
Endangered Species	3.10	1.30
Green House Gas Emissions	3.05	1.25
Global Climate Change	2.72	1.37

To better understand forest landowner perceptions of biofuels, several statements were shown to the group and asked to indicate their agreement/disagreement. Mean

responses for these statements ranged from 4.30-2.62 (Table 7). The forest landowner respondents strongly agree that some types of biofuels were better for the environment than others (mean=4.30). Table 7 also shows that forest landowners strongly support the procurement of forest stands for biofuel production if a sustainable harvest is utilized, where “for each tree cut another is replanted” (mean=4.07). Biofuels and biodiesel were viewed as having a positive environmental benefit when compared to gasoline. Respondents indicated a slightly negative perception for government subsidy for manufacturing of biofuels (mean response 2.81). This finding is consistent with another study that found that forest landowners preferred tax based policies over subsidy based support (G.C. & Mehmood, 2010).

Table 7. Respondents' general perceptions of biofuels based on an agreement scale (1=strongly disagree to 5=strongly agree) (n=42)

Biofuel Topics	Mean	Std. Deviation
Some types of biofuel are better for the environment than others	4.30	0.80
I would support the cutting trees for biofuels if for each tree cut another was replanted	4.07	1.10
Biodiesel has a lower environmental impact than gasoline	3.56	0.93
Biofuels have a lower environmental impact than gasoline	3.53	1.05
I would like the government to provide me with more information about biofuels	3.23	1.13
I think the government should subsidize the manufacturing of biofuels	2.81	1.45
Biofuels are not environmentally friendly (they take more energy to make than it is worth)	2.79	1.08

Study respondents were asked to indicate what sources of energy they considered renewable/sustainable. The list of energy sources was generated from the Department of Energy’s (DOE) website under their Energy Sources section. The top six energy sources (in terms of respondent perceived renewability or sustainability) were reported to be solar (93.0%), wind (90.7%), hydroelectricity (88.3%), geothermal (79.0%), tidal (76.7%), and biofuel (65.1%). Biofuel scored higher than only one other renewable energy (hydrogen, 34.8%). A summary of responses can be found in Figure 4.

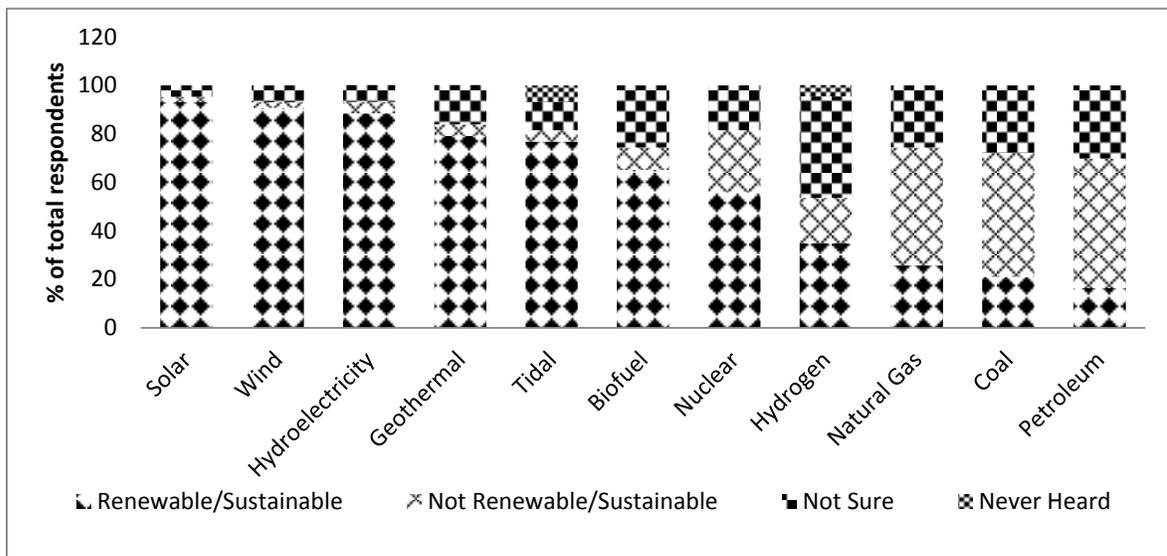


Figure 6. Respondent perceptions of renewable/sustainable nature of energy sources (n=42)

5.4.4 Perceptions of Genetically Modified crops/trees

Biotechnology has the ability to improve the yields of forest-based feedstocks and other energy dedicated crops that will help meet the rising demand of biofuels (Sedjo, 2011). Biotechnology applications in the forest industry include genetically modified (GM) trees

and crops (short-rotation, low lignin crops and trees, etc.) that are likely to enhance growth and yield and limit negative traits in plants/trees. Respondents were asked to report their agreement and disagreement (on a five-point agreement scale, 1=strongly disagree to 5=strongly agree) with various GM statements, some of which focused on bioenergy applications (Table 8). On a five-point agreement scale, Table 8 shows information on agreement by combining the top 2 responses (response 4 and 5 on a 5 point scale where 5=strongly agree and 4= agree), disagreement by combining the bottom 2 responses (response 1 and 2 on the five point scale where 1=strongly disagree and 2= disagree) and neutral (response 3 on the five point scale). Respondents are most accepting of GM tree/crop applications when a direct benefit was linked with this use and application. Respondent landowners indicated most support for GM trees for biofuel production if it led to a decrease in foreign oil imported by the US (80% of respondents agree). Other tradeoffs supported by landowners included the use of GM for biofuels assuming it would lower the environmental impact (79% of respondents agree) and GM used for species restoration (74% of respondents agree). About 80 percent of respondents responded negatively to the statement that genetic modification was unethical. Questions not directly linked to tradeoffs had much larger variation in agreement and disagreement with many respondents falling in the neutral category. This neutrality in response may be attributed to uncertainty and potential unknown effects surrounding GM technology and its application (Fischhoff & Fischhoff, 2002; Han & Harrison, 2004).

Table 8. Respondents' general perceptions of the genetic modification with specific reference to biofuel production (n=42)

Note: *Agree = all respondents who indicated a 4 or 5 on a five point agreement scale (1=strongly disagree, 5=strongly agree); Disagree = all respondents who indicated a 1 or 2 on the five point agreement scale, Neutral= all respondents who indicated a 3 on a five point agreement scale

Genetic Modification Topics	Agree*	Neutral*	Disagree*
I would support genetically modified trees used for biofuels (as a transportation fuel) if it meant that we didn't have to import oil from overseas	80%	5%	15%
I would support genetically modified trees/crops if it allowed the biofuel industry to lower their environmental impact	79%	5%	16%
I would support genetically modified trees if they were used for species restoration, or to resist diseases (e.g., American Chestnut)	74%	10%	15%
Genetically modified trees/crops have the ability to provide an adequate supply of biomass to create biofuel	51%	28%	21%
Genetic modifications of trees/crops will be required to meet the natural resource demands of the future	46%	33%	21%
I would support genetically modified trees/crops if only non-food source feedstocks were used for biofuel production	36%	26%	38%
Genetically modified trees will alter the characteristics of natural trees	23%	26%	51%
I would support genetically modified trees/crops only if they had the ability to produce at least 2-3 times the yield as conventional crops	10%	36%	54%
Genetically modified crops are harmful to us	15%	26%	59%
Growing genetically modified trees is unethical	8%	13%	79%

Forest landowners were also asked to indicate any additional comments or concerns they had about the biofuels or energy industries in general, through an open-ended question. Open-ended responses provide information to help further elaborate on certain concerns and statements made by respondents earlier in the survey or may reveal important concerns not directly addressed within the questionnaire. Although only the most passionate respondents are most likely to respond compared to others, the results echo some uncertainties and themes discussed earlier. A total of 13 open-ended responses were compiled from the

landowner group. The following represents a few selected comments from the respondents verbatim:

“Growing trees for biofuels is not the only option. Woody biomass from urban landscaping and from forest thinning for fuel reduction can provide enough fuel for local use in waste-to-energy or biomass burners. Wood energy can never be seen as a replacement, but rather as part of a portfolio of local sources. Denmark and Germany have got this down.”

“I don't think we know enough about the implications of genetic modification yet. I am not yet able to jump on that bandwagon. In fact, I would like to see us work more in harmony with the natural world. I have no problem with hybrids, with good genetic breeding, but tinkering with DNA and genes still feels unproven.”

“Change in land use for fuel feedstocks is a concern. I support use of trees as a biofuel if a (comparable) clean burning fuel can be produced. I am not convinced biofuels are necessarily better environmentally than fossil fuels. A blended approach (natural gas, water, wind, nuclear, biofuel, solar, oil etc.) seems most effective.”

“The US should strive to be energy independent. All fuels must be economically viable without government subsidies to be sustainable.”

“I am concerned that the amount of energy expended to create biofuels does not sufficiently exceed the energy produced by the biofuels.”

”I am concerned about taking land out of production for food and fiber and having it redirected into biofuels. I think biofuel production should come from sources which currently have no market value such as tree tops and brush such as yaupon and gallberry.”

A summary of all open ended comments show forest landowners’ common concerns surrounding the biofuel industry related to land use change, environmental benefits/impacts, and effects of genetic modifications of feedstocks.

5.5. Conclusion

Forest landowners will be key players as the economy moves towards bio-based sources of energy, including liquid fuels. It is evident that the opportunity for forest based biofuel production is met with some skepticism by landowners. Forest landowners are in support of cutting trees for biofuel production as long as a sustainable approach was taken (for each tree cut another was replanted). Respondents were not in support of government subsidy for the manufacturing of biofuels. Respondents were also highly concerned about reducing US dependence on foreign sources of oil and maintaining resource availability for future generations, even in relation to the benefits of using GM trees and crops for biofuel production. Concerns for environmental sustainability of these products (biofuel and related products) needs to be further explored and subsequently conveyed to landowners and consumers by reputable sources.

Applications of genetic modifications to feedstocks for biofuel production are an issue approached with some polarity by landowner respondents. This group reported that GM use is not unethical but tradeoffs have to be made for its use. Forest landowners indicated support to GM trees and crops for biofuels if it meant reducing environmental impact and US energy independence as indicated earlier. Uncertainty to GM related risks and benefits perceived by forest landowners must be addressed by the government as well as the industry. More research focusing on the potential adverse effects genetic modification may have in terms of human health and natural ecosystem impacts may also be necessary for widespread market adoption. Responsible sourcing and use of forest fiber (trees or GM trees) for bioenergy is reported by many researchers and organizations to help increase market access for forest landowners who can manage their land sustainability for high quality timber and other uses (Costanza & McCord, 2009; McDonald, Fargione, Kiesecker, Miller, & Powell, 2009).

The forest landowners will play a key role in the future of the cellulosic biofuel industry. Their perception of the product, market and feedstocks, in addition to the economics and growth in the industry will affect the availability and supply of raw materials for the industry and make it a success.

5.6. Acknowledgments

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6. Stakeholder perceptions of genetic modifications and its role in feedstock enhancement for biofuel production: A segmentation perspective³

Steven Tyler Pires^a, stpires@ncsu.edu, Sudipta Dasmohapatra^a, sdasmoh@ncsu.edu, Toddi

Steelman^b, tasteelm@gw.ncsu.edu, Adam Costanza^c, adam.costanza@forestbiotech.org, Susan McCord^c,

susan.mccord@forestbiotech.org

^aNorth Carolina State University—Department of Forest Biomaterials, Campus Box 8005 Raleigh, NC 27695

^bNorth Carolina State University—Department of Forestry and Environmental Resources, Campus Box 8008 Raleigh, NC 27695

^cInstitute of Forest Biotechnology, 140 Preston Executive Drive, Suite 100G Cary, NC 27513

Abstract

Genetic modification has long been an attractive method for meeting the natural resource and other demands of consumers in many industries; however negative social perceptions are often seen as a hindrance to its successful implementation and use. This study sought to identify perceptions of various stakeholder groups regarding the use and application of genetic modifications (GM) in general and its role in feedstock enhancement in biofuel

³ Potential Journal: Society and Natural Resources

production. Stakeholder groups included Southeastern residents consisting of consumers, industry professionals, researchers, non-government organizations, and forest landowners. Data from stakeholders was collected via an electronic survey during Spring/Summer of 2010, resulting in 605 responses. Results of the study indicate that most respondents are neutral in response towards questions regarding genetically modified trees/crops their various applications. By use of a cluster analysis, four distinct segments of stakeholders were identified with different perceptions about GM trees/crops specifically related to GM application for biofuel feedstocks. Government and industry professionals need to use different informational, promotional and targeting strategies to meet the needs and characteristics of each of the segments.

6.1. Introduction

The US Department of Energy and the US Department of Agriculture released a study titled, “Biomass as feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply” (2005) which is commonly referred to as the “Billion ton study.” The Billion Ton Study evaluates whether the land resources in the United States have the potential to supply enough biomass to accomplish a 30% reduction in our country’s present petroleum consumption in order to reduce US greenhouse gas emissions. To accomplish this goal (a 30% reduction) using a variety of feedstocks, including all plant and plant derived materials, would require approximately 1 billion dry tons of biomass feedstock per year (Perlack, et al., 2005). The Billion Ton Study also concludes,

with minimal changes in land use, forestland and agricultural land have the potential to provide 1.3 billion dry tons of biomass per year.

As populations increase, the level of demand for bioproducts and natural resources is also likely to increase. To offset these increases in demand, intensive management of fast-growth softwood and hardwood plantations will be critical to both the bioproducts (Rousseau, et al., 2005) and biofuel industries. Using genetically modified (GM) technologies in feedstocks (to improve cell wall characteristics, yield and stress tolerance) is a key component of the US Department of Energy's long term strategy to meet the demands of increased production of biofuels (Chapotin & Wolt, 2007). Chapotin, et al., (2007) also point out that the technological advancements for meeting these biomass demands are available, but they rarely consider problems associated with the use of these GM crops such as regulatory approval, market adoption, and public acceptance. The purpose of this study is to seek an understanding of the issues concerning market adoption and public perception of GM trees and crops in general, and specifically its role in enhancing feedstocks for the bioenergy industry.

6.1.1 Genetic Modification and Social Acceptance

Societal research concerning biotechnology and consumer acceptance suggests that many consumers do not outright reject genetic engineering, but are often skeptical of how and where these technologies will be applied (Blaine, et al., 2002; Lemaux, 2009). A study by Blaine et al. (2002) involved an extensive literature review focusing on the public perceptions of biotechnology in food applications in six countries (including the US). This

study found that consumers are becoming increasingly aware of GM applications yet uncertainties on potential unintended consequences of these products remain. This study also shows that increasing the amount of science and technology information related to GM is likely to promote acceptance (Blaine, et al., 2002). However, this study was conducted on food-based GM applications.

A study on the consumer preferences for GM derived animal foods in the UK (n=582) showed three distinctly different segments of consumers in regards to their perception of GM foods (Kontoleon & Yabe, 2006). The first segment was found to be highly trusting of available GM information, not environmentally concerned, and not ethically opposed to GM applications. The second segment was found to be highly concerned with the ethical and environmental considerations surrounding GM. The third segment was strongly concerned with ethics against the use of GM and did not trust any available information.

Most of the previous studies on social perceptions of biotechnology (GM) have been focused on the food industry (and with the consumer stakeholder group) with very little information about GM in non-food applications in agriculture and forestry (and any other stakeholder group). With current emphasis on the use of GM based sources for energy applications, and increased availability of information, it is important to gather information from a diverse group of stakeholders about their perceptions of GM crops and trees as well as GM application in biofuels industry.

6.2. Objectives

The objective of this research was to assess the perceptions of the public (consumers, industry, government, academia, non-government, forest landowners) about genetic modifications in trees/crops and to identify their support or opposition to the use of GM feedstocks for biofuels production. The specific objectives of this study are as follows:

- To understand stakeholder perceptions of GM crops and trees;
- To identify if distinct segments based on GM of crops and trees exist as well as suggest promotional strategies to target each of these groups;
- To inform policy initiatives and discussions surrounding genetic modifications especially on its use for biofuel applications.

6.3. Methodology

6.3.1 Instrument design

An electronic survey instrument was designed consisting of multiple choice, open-ended, and 5 point likert scale opinion questions. All answer options to multiple choice and likert scale questions were randomized to avoid any bias in response. The survey consisted of questions including: 1) demographics, 2) general perceptions of the environment and renewable energies, 3) GM based general statements and its role in biofuels industry. Before finalizing the survey, a random sample of 35 participants was selected for an initial pilot test from the stakeholder categories to identify any question wording, length and interpretation problems.

6.3.2 Stakeholder database

Contacts for each of the stakeholder categories were developed for data collection using the following strategy:

- *Consumers*: randomized consumer emails from an electronic consumer database were purchased from a third party marketing firm
- *Forest Landowners*: an electronic link of the survey was generated for distribution in the Forest Landowner Associations list serve in their monthly membership update
- *Government*: contacts were obtained through search of public records and through project partner networks throughout the Southeast
- *Universities*: random sample of researchers were selected from universities across the Southeast (collected from the web)
- *Industry*: contacts were generated from various bioenergy websites and conferences
- *Non-government*: contacts were obtained from public records from the web (including contacts from environmental non-profit entities)

6.3.3 Data Collection

Data for this study were collected from April 1, 2010 through July 31, 2010 and a total of 38,935 email invitations were sent (Table 9). Each stakeholder category had 30 days to respond after the initial invitation was sent. After two weeks, a reminder message was sent to participants to encourage participation. At the end of the data collection period, 605

completed questionnaires were obtained. Between 21%-32% response rates were obtained from the government, non-government, and industry contacts, whereas consumer and forest landowner groups had much lower response rates. It should be noted that the forest landowner contacts did not receive a direct email similar to other stakeholder groups, which may have contributed to a low response rate for that group. Random sample e-mail surveys are likely to be ignored by respondents (Klassen & Jacobs, 2001), which may explain the lower response rates in the consumer category. A summary of invitation and response rate data can be found in Table 9.

Table 9. Survey completes (n=605) and response rate by stakeholder category

Stakeholder Category	# of Invites Sent	Total # of Responses	Response Rate
Consumers	34811	431	1.2%
Forest Landowners	3620	43	1.2%
Government	57	12	21.1%
University/Industry	258	58	22.5%
Non-government/non-profit	189	61	32.3%

6.4. Stakeholder perceptions of general environment and energy

When asked about stakeholder’s concern related to several environment and energy statements on a 5-point concern scale (1=not at all concerned to 5= very concerned), respondents indicated that they were mostly concerned about US dependence on foreign oil

and economic concerns (price of energy). Table 10 (sourced from Chapter 4) shows the means and standard deviations of the concern statements.

Table 10. Summary of responses towards environmental concern topics (1=not at all concerned to 5=very concerned)

Concern Topics	Mean	Standard Deviation
US dependence on foreign oil	4.5	0.8
Resource availability for future generations	4.3	0.9
Pollutants in the environment	4.3	0.9
The price of energy (e.g., electricity, natural gas, etc.)	4.2	0.9
Price of transportation fuels	4.2	0.9
Increasing global population	3.9	1.1
How much energy you are using	3.8	1.0
Endangered species	3.8	1.2
Greenhouse gas emissions	3.8	1.2
Global climate change	3.7	1.3
Food availability/shortage	3.7	1.2
Drilling more gas and oil wells in the US	3.6	1.3

6.5. Stakeholder perceptions of GM-based benefits and risks statements (including biofuels application)

To identify respondent understanding, interest or aversion to GM in trees and crops and its role in the biofuels industry, several statements were shown to the contacts and they were asked to indicate their agreement with those statements (on a five-point scale, 1=strongly disagree to 5= strongly agree) (Table 11). Table 11 is organized such that the top 2 scale points (5=strongly agree and 4=agree) in the five point scale was combined to form the agree column (column 1), the second column is the neutral column (3= neutral) and the third column is the combination of bottom 2 scale points (1= strongly disagree and 2= strongly agree). The table should be interpreted as follows: 64.7% of all respondents indicated either a 5 (strongly agree) or a 4 (agree) for statement 1 (“I would support genetically modified trees if they were used for species restoration, or to resist diseases”).

Table 11. Perceptions of genetic modifications in trees and crops (n=605)

Note: *Agree = all respondents who indicated a 4 or 5 on a five point agreement scale (1=strongly disagree, 5=strongly agree); Disagree = all respondents who indicated a 1 or 2 on the five point agreement scale, Neutral= all respondents who indicated a 3 on a five point agreement scale

GM statements	Agree*	Neutral*	Disagree*
I would support genetically modified trees if they were used for species restoration, or to resist diseases (e.g., American Chestnut)	64.7%	24.4%	10.9%
I would support genetically modified trees used for biofuels (as a transportation fuel) if it meant that we didn't have to import oil from overseas	60.5%	25.8%	13.7%
I would support genetically modified trees/crops if it allowed the biofuel industry to lower their environmental impact	59.6%	27.0%	13.4%
Genetic modifications of trees/crops will be required to meet the natural resource demands of the future	40.7%	40.1%	19.2%
I would support genetically modified trees/crops if only non-food source feedstocks were used for biofuel production	38.2%	40.8%	21.0%
Genetically modified trees will alter the characteristics of natural trees	31.2%	42.0%	26.8%
I would support genetically modified trees/crops only if they had the ability to produce at least 2-3 times the yield as conventional crops	29.4%	41.1%	29.5%
Genetically modified trees/crops have the ability to provide an adequate supply of biomass to create biofuel	28.0%	56.8%	15.2%
Genetically modified crops are harmful to us	17.5%	42.1%	40.4%
Growing genetically modified trees is unethical	13.4%	33.7%	52.9%

As shown in Table 11, between one-fourth to over 56% of respondents reported that they were neutral to the GM statements. This suggests that most of these respondents may have been uncertain about GM and did not have sufficient information to make decisions one way or the other. The top three positive statements with support for GM trees include: 1) if used for species restoration or prevent diseases (64.7% of respondents agree or strongly agree); 2) for biofuels if it meant not importing oil from overseas (60.5% agree or strongly agree); 3) if it allows the biofuels industry to lower its environmental impact (59.6% agree or strongly agree). Table 11 also indicates that about 53% respondents feel that GM trees are not unethical however about one-third are neutral about this.

6.6. Respondent perceptions of GM trees and crops: A segmentation of stakeholders

It is well documented that the consumer acceptance of GM products is significantly different depending on demography, attitudes/perceptions, and application (Verbeke, 2007). To identify if there are distinct segments of GM perception among the respondents, a segmentation analysis was developed using key variables from the survey. A segmentation analysis is an analysis that identifies distinct groups from a large population that are homogeneous in one or more characteristic (including their attitudes or behavior) (Hair, Black, Babin, & Anderson, 2010).

As a first step to the segmentation, a list of key variables to be included in the segmentation analysis was determined, including: GM statements, environment and energy concern statements, and various demographic variables (type of stakeholder and gender). These demographic variables were found to be most significant in segmentation. Since the variables to be included in the segmentation need to be as uncorrelated as possible (so that the segmentation model is efficient), a factor analysis was first conducted of the list of statements (GM and concern statements, separately). The aim of the factor analysis is to reduce the number of variables to a manageable set for further analysis (such as segmentation) by finding a natural grouping (factors) among the variables (Hair, et al., 2010). In other words, if there are different GM statements, some statements could be correlated so they naturally group into one underlying factor that measures the same dimension. For example, if there are three or four price related statements, the respondents are expected to

respond to them similarly, so they may be naturally grouped into one underlying dimension “PRICE.”

6.6.1. Factor analysis results

The GM statements (in Table 11) and general concern about environment and energy (Table 10) were both subjected separately to factor analysis in SPSS software. Using a Principle Component method with varimax rotation, three factors were identified for the GM statements explaining 76% variance in the data (Table 12). The reliability of the variables included under each factor is good to acceptable (0.86, 0.73, and 0.50). Reliability of different items are measured using Chronbach’s Alpha which shows how reliable each of the variables are in explaining a particular factor. Reliabilities above 0.50 are considered acceptable. The three factors consisting of different variables were named as “Benefit and tradeoff based GM support”, “Harmful effects of GM”, and “GM supply concerned.” Table 12 shows the factor loadings of each of the variables describing the factors. In simple terms, the factor loadings show the correlation of a variable with a particular factor that they explain.

Table 12. Factor results in reference to perceptions of genetic modifications of feedstocks

GM Question Statements	Factors & Loadings			Chronbach's alpha (reliability)
	Benefit and tradeoff based GM support	Harmful effects of GM	GM supply concerned	
I would support genetically modified trees if they were used for species restoration, or to resist diseases (e.g., American Chestnut)	0.84			
I would support genetically modified trees used for biofuels (as a transportation fuel) if it meant that we didn't have to import oil from overseas	0.81			0.86
I would support genetically modified trees/crops if it allowed the biofuel industry to lower their environmental impact	0.80			
Genetically modified trees will alter the characteristics of natural trees		0.85		0.73
Genetically modified crops are harmful to us		0.77		
I would support genetically modified trees/crops only if they had the ability to produce at least 2-3 times the yield as conventional crops			0.88	0.50
Genetically modified trees/crops have the ability to provide an adequate supply of biomass to create biofuel			0.60	

A similar factor analysis of the environment and energy concern statements show three factors explaining 73% variability in the data with good to acceptable reliabilities (0.87, 0.86, 0.48). The three factors were named based on the variables explaining the factors: “Environmental concerns”, “Economic concerns”, and “Resource concerns.” Table 13 shows the factor loadings for the variables included in the factor analysis with the reliabilities of each factor. It should be noted that some variables (statements) that did not explain or describe any of the factors were removed from the factor analysis to determine the best factor model.

Table 13. Factor results in reference to respondent general environmental concerns

Environmental Concern Topics	Factors & Loadings			Chronbach's alpha (reliability)
	Environmental concerns	Economic concerns	Resource concerns	
Green House Gas Emissions	0.86			
Global Climate Change	0.82			
Pollutants in the Environment	0.80			0.87
Endangered Species	0.78			
How much Energy you are Using	0.64			
The Price of Energy (e.g., Electricity, Natural Gas, etc.)		0.92		0.86
Price of Transportation Fuels		0.92		
Drilling More Gas and Oil Wells in the US			0.85	0.50
Food Availability/Shortage			0.64	

6.6.2. Segmentation results

Using the six factors obtained from above, variables that were excluded from the factor analysis from Table 12 and 13, and two demographic variables (type of stakeholder and gender), a cluster analysis was conducted (in SPSS using two-step cluster method), four segments were obtained. It should be noted that many segmentation solutions were analyzed, including other demographic variables from the dataset but the above variables provided the best segmentation model with distinct segments. The survey included many other questions related to willingness to purchase biofuels from various types of feedstocks (food and non-food), sources for energy and environment information, etc., which were additionally used as variables to describe or profile the segments. The four segments are described in the

following sections and a summary is provided in Table 14. The table represents all the variables included in the segmentation model to get the final four segment solution.

Table 14. Segmentation summary

Note: In segment 3, the 62.9% other includes researchers, industry, government, and the remaining 36.1% comprising forest landowner stakeholder groups. The numbers contained in the table below represent regression coefficients extracted from the prediction equation for segmenting the variables. Positive numbers show a positive perception (higher numbers represent stronger positive perceptions) and negative numbers show negative perception for the given factor (lower numbers represent stronger negative perceptions). The other continuous variable means are on a five point scale (1=strongly disagree, 5=strongly agree).

Segmentation Variables	Variable Type	Segment 1 (35%)	Segment 2 (13%)	Segment 3 (18%)	Segment 4 (34%)
		Resource and economic concerned females	GM adverse environmentalists	Benefit and tradeoff driven GM supporters	Male GM supporters for increased supply
Stakeholder	%	100% Consumers	61.50% NPO/NGO	62.90% Others	100% Consumers
Gender	%	100% Female	61.50% Male	83.10% Male	100% Male
Benefit and tradeoff based GM support	Mean	0.00	-1.12	0.36	0.17
Harmful effects of GM	Mean	0.11	0.40	-0.64	0.04
GM supply concerned	Mean	0.25	-0.77	-0.30	0.33
Genetic modifications of trees/crops will be required to meet the natural resource demands of the future	Mean	3.40	2.15	3.65	3.38
I would support genetically modified trees/crops for biofuel production if only non-food source feedstocks were used for biofuel production	Mean	3.38	1.91	3.27	3.47
Growing genetically modified trees unethical	Mean	2.60	3.62	1.62	2.22
Environmental concerns	Mean	0.11	0.26	-0.16	-0.10
Economic concerns	Mean	0.37	-0.63	-0.46	0.15
Resource concerns	Mean	0.17	-0.04	0.04	-0.19

Segment 1—Resource and economic concerned females (Segment size=173, 35%)

Demography

This segment consists of 100% female consumers. Over 69% of this group is 55 years of age and over with 56% of the household incomes ranging from \$35,000 to \$75,000. This consumer segment had approximately 55% of its respondents with a 2 year college degree or less.

Attitude towards genetic modifications

Data from the segmentation analysis suggest that segment 1 only support the use of genetic modifications as feedstocks for biofuel production provided that only non-food source feed stocks were used (mean=3.38 on a 5 point agreement scale). Applications of GM in foods are certainly a contentious topic (Verbeke, 2007), especially for the female consumer possibly due to their fears of these products harming their families. The resource and economic concerned female segment show a willingness to support GM for biofuel applications if this reduced the dependence on foreign oil (mean=3.80). This segment is largely neutral (indicating uncertainty) on a majority of the other GM based statements.

Perceptions and concern for the environment

This group is highly concerned about resource issues surrounding energy consumption and food availability/shortage. This group is also highly concerned about price related energy topics (price of transportation fuels and electricity, mean ratings of 4.58 and 4.57, respectively).

Other notable characteristics

This group is most willing to purchase biofuel from corn (77.8%) when compared to the other segments. This group does not seem concerned about using corn for biofuel production, but the application of GM to food for biofuel production causes them to reject these products. Applications of GM to food have long been a point of concern to many due to potential negative health effects due to consumption of these foods (Frewer, Miles, & Marsh, 2002). A large majority of this segment obtains their information about energy and the environment from television, word of mouth, and utility companies (71.1%, 54.4%, and 49.1%, respectively).

Segment 2—GM adverse environmentalists (segment size=65, 13%)

Demography

This segment consists of 61.5% males and all respondents are representatives of non-profit/non-government organizations. Approximately, 45% of the respondents in this segment are 44 years of age or less, with 58% having household incomes between \$50,000 and \$100,000. This segment is highly educated, with 72% of the population having a 4 year college degree or higher.

Attitude towards genetic modifications

The “GM adverse environmentalist” segment is strongly opposed to the use of GM trees and crops in almost all applications. The respondents within this segment provided highest mean rating to the factor “Harmful effects of GM,” thus indicating that growing GM trees is harmful to the environment if increased use does take place. The respondents belonging to this segment also consider that growing GM trees/crops is unethical (highest mean=3.62 among all segments). This segment is highly unlikely to support GM applications

based upon perceived benefits and tradeoffs including for biofuels related applications (Table 14).

Perceptions and concern for the environment

Results of the segmentation shows that this group strongly places a high importance to the environment, so much so that price becomes a non-issue when considering environmental benefits and impacts. This is shown by the largest mean value for the environmental concerns factor (0.26) and the lowest mean value for the economic concerns factor (-0.63) (Table 14).

Other notable characteristics

Data for the “GM adverse environmentalist” segment suggests a high degree of skepticism around biofuel (in general) and the use of feedstocks for biofuel production. This group is significantly less willing to purchase biofuel from various feedstocks when compared to the other segments. This segment is also the most unsupportive towards the use of trees and GM trees for biofuel production (only 25.4% and 22.6% willing to purchase, respectively).

The respondents for this segment obtain a majority of their information about energy and the environment from non-profit organizations (mail and websites), documentaries, and blogs/social networking sites when compared to other segments. Biofuel industry professionals may consider utilizing the aforementioned media sources when distributing promotional and informational materials.

Segment 3—Tradeoff and benefit driven GM supporters (segment size=89, 18%)

Demography

The “tradeoff and benefit driven GM supporters” include 83.1% males and comprises 63% researchers, industry, and government stakeholders and 37% forest landowner stakeholder categories. This segment has 63% of its population falling within the age range of 45-64 years of age and 66% having household incomes between \$75,000 and \$100,000. This segment is highly educated with 68.5% of the population with a graduate degree.

Attitude towards genetic modifications

The respondents belonging to this segment are highly supportive of GM in terms of the benefits yet are looking for positive tradeoffs to energy and environment when using GM trees and crops (largest mean value for GM Benefits/tradeoff factor = 0.36) (Table 14). This segment strongly disagrees that the growing of GM trees/crops is unethical (mean=1.62) and that GM will have harmful effects to society and the environment (mean= - 0.64).

Perceptions and concern for the environment

This particular segment is not that concerned about the environment (lowest mean value for Environment Concerns factor=0.16)

Other notable characteristics

Compared to every other segment, majority of the respondents of this segment indicate their awareness and willingness to purchase biofuels from trees as feedstocks (60.7% of respondents). This segment was also the most willing to purchase biofuels from any non-food source feedstock (over 84% respondents willingness to purchase for biofuel from wood waste, landfill waste, crop waste, grasses, algae, trees, and GM trees).

The respondents of this segment reported that they obtained most of their energy and environment related information from newspapers, scholarly journal articles, radio, and schools/universities.

Segment 4—Male GM supporters for increased feedstock supply (Segment size=168, 34%)

Demography

This segment consists of 100% male consumers with 57.8% of the respondents having completed at least a 4 year college degree.

Attitude towards genetic modifications

The respondents belonging to this fourth segment are supportive of GM trees and crops mostly due to the benefits their applications will have for increasing the supply of feedstocks for biofuel production (highest mean value for supply for GM factor= 0.33). This segment is also not supportive of using food sourced feedstocks for biofuel production. The respondents of this segment are neutral when considering the harmful effects of using GM trees and crops (so it will be essential to provide them information in this area).

Perceptions and concern for the environment

This segment seems most concerned about US dependence on foreign oil (mean=4.54) but they are least concerned about the resource availability for future generations (lowest mean for Resource Concerns factor =-0.19).

Other notable characteristics

The respondent males of this segment are more likely to purchase biofuels sourced from soybeans or potatoes as compared to any other segment. The respondents belonging to

this segment indicated that they received most of their information about energy and the environment from either television or magazines.

6.6. Conclusions

Approximately 60 percent or more of respondents agree to support GM trees and crops if it resulted in species restoration or prevention of diseases, and also use of GM as feedstocks if it reduces foreign oil dependence or for lowering environmental impact. However, results of this study show that stakeholders are neutral when considering most other applications of GM trees and crops possibly due to a lack of concrete or accurate information.

Four segments of stakeholders were found that have distinct attitudes and demographic differences. This suggests that each of these segments perceive and rationalize the topics of GM and environmentalism with distinctly different focus.

Understanding how different groups of individuals perceive complex and often contentious concepts (e.g., genetic modifications for biofuel feedstocks) is highly important when considering how to target each of these segments for success. When marketing these products to female consumers (the first segment), information regarding non-GM food sourced feedstocks for biofuels should be promoted. In addition, resource availability for future generations should be stressed in promoting biofuels related information to this group. Since this group is sensitive towards price of energy, key messages for this segment should also include economic factors. Yet another example for targeting is that both the first and fourth consumer segments are neutral when considering the harmful effects of GM which

may be a barrier for the success for these products until industry can ensure their safety. Each of these segments use different sources of information for energy and the environment that could be used for targeting and promoting the negative perceptions of each of these groups for success of GM trees and crops.

Although most of the patrons of these new fuels will be consumers, it is still highly important to understand how other stakeholder categories perceive GM and their applications. The “GM adverse environmentalist” group was mostly comprised of the non-profit/non-government organization stakeholder category. This group is known to be highly passionate in their opposition to the use and applications of GM. Successful implementation and use of GM will require careful collaboration between these non-profit/non-government organizations and policy makers. Without some form of compromise between industry, government, and NPO/NGOs, the success of implementing GM based solutions to feedstock supply related issues is likely to be difficult.

The third segment are supporters of GM and see opportunity in the use and application of GM for reducing our foreign oil dependence, increasing our supply of biomass, lowering environmental impact of agricultural activities, disease resistance, and species restoration. This group of supporters is highly educated, perhaps giving insight to an increased focus in education on the topic of GM in standard K-12 curriculums.

Blaine et al. 2002 showed that acceptance of GM tends to be conditional and closely related to trust in regulatory agencies, and there is consensus regarding the need for increased government and industry interaction with the public concerning the biotechnology issues (Blaine, et al., 2002). Thus, an overall success of the GM market for trees and crops will

depend on an integrated marketing campaign with collaboration from consumer groups, non-profits, education and research organizations, industry and the government.

6.6.1 Policy implications

As stated in EISA 2007, the increased use of GM technologies in feedstocks to is a key component of the US DOE's long term strategy to meet increasing biomass demands from biofuel production. The social perception of any technology has the ability either promote or hinder successful implementation and use. An in-depth understanding of each of the GM segments will inform policy makers to predict potential road blocks during the GM implementation.

6.6.2 Future work

Future work in this area could benefit from an increased sample size from the researcher/industry and the non-profit stakeholder categories. Similar studies should take place in other regions of United States (e.g., Northeast, Northwest, Southwest, Midwest, etc.) to identify if similar GM-based attitudinal segments exist in the regional marketplace (to confirm the findings of this study).

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