ABSTRACT

DUPEY, LAUREN NICOLE. A Social Life Cycle Analysis: The Social Impacts of Bioenergy Facilities on Nonindustrial Private Forest Landowners in the Southeastern United States. (Under the direction of Dr. Robert Bardon).

Nonindustrial Private Forest (NIPF) landowners in the southeast own a substantial portion of forestland that has the potential to be harvested for bioenergy production. The southeastern states also have a number of bioenergy production facilities. The combination of these two factors makes NIPF landowners in the southeastern states excellent candidates for research on bioenergy perceptions, attitudes and forest management behaviors. A Social Life Cycle Analysis (SLCA) was conducted to understand if normative social influence and/or success level of a proximal bioenergy facility impacts NIPF perceptions, attitudes and forest management behaviors related to bioenergy.

The Social Life Cycle Analysis data was gathered through a forest landowner survey. A survey was mailed to 5,286 Nonindustrial Private Forest landowners, who own property within a 60-mile procurement radius of specific bioenergy facilities. The sample encompassed 49 counties across 4 southeastern states. Results from the SLCA were overall neutral in emotional investment, recreational impacts and resource conservation categories. Social well-being, social acceptability and external trade were rated as positive, whereas, peer influence and profitability were rated as negative.

Results from this study showed no significant differences in landowner perceptions, attitudes and management behaviors between a facility with a positive connotation and negative press (Enviva) and a facility with a negative connotation and negative press (KiOR). Irrespective of landowner grouping, landowners had strong agreement towards the following bioenergy statements: Most landowners support and should consider supplying biomass

feedstock, bioenergy from trees is more environmentally friendly and the facility has an overall positive impact, which will outweigh the negative impacts over time.

T-tests placed landowners into groups, irrespective of site, to further analyze social normative influence and agreement towards bioenergy statements. Although normative social influence does not appear to impact NIPF landowners, NIPF landowners tend to have positive opinions about the bioenergy facility and the level of bioenergy support from other forest landowners in the community. This level of support is amplified with NIPF landowners who have a management plan, those who draw income from their forestland and those who purchased their forestland.

Results from this study can be used to better understand how NIPF landowners in the southeastern states view local bioenergy facilities, and what influences these views. This information can be used in landowner outreach and education through formal extension programs, such as Cooperative Extension, or other institutions. This information can also be used to further evaluate NIPF landowner cognitions and behaviors regarding local bioenergy harvesting. Further studies need to be conducted to further analyze NIPF landowner trends in regards to bioenergy topics.

A Social Life Cycle Analysis: The Social Impacts of Bioenergy Facilities on Nonindustrial Private Forest Landowners in the Southeastern United States

by
Lauren Nicole Dupey

A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the degree of
Master of Science

Forestry

Raleigh, North Carolina

2015

APPROVED BY:

_____	_____
Dr. Robert Bardon Committee Chair	Dr. Sudipta Dasmohapatra
_____	
Dr. Dennis Hazel	

DEDICATION

To my cats, Estes and Yukon.

BIOGRAPHY

Lauren Nicole Dupey was born to Denise Marie Piquette and Mark Wayne Dupey in Kenosha, Wisconsin on October 11, 1990. Lauren grew up in Pleasant Prairie Wisconsin, a small village a few blocks off Lake Michigan. As a child, Lauren enjoyed fishing, hiking and camping during family vacations to Colorado and the Upper Peninsula of Michigan. In high school, she helped form the schools second Environmental Club after leaving weekly meetings dissatisfied with the level of environmental action being taken. Her love for the outdoors led her to the Upper Peninsula of Michigan (U.P.), where she started hunting on her family property and backpacking in the Porcupine Mountains. After settling into the snowy wonderland that is the U.P., Lauren purchased her first home and began her bachelor's degree in Psychology and Environmental Studies at Michigan Technological University. Lauren had many successful academic endeavors at Michigan Tech -but only one lit a spark in her nature loving heart- a research assistantship with Dr. Kathy Halvorsen. During the last three years of her undergraduate degree Lauren studied Nonindustrial Private Forest landowners in the Upper Peninsula and their attitudes towards bioenergy. The constant support and guidance from Dr. Halvorsen and her academic advisor Dr. Susan Amato-Henderson, pushed Lauren to pursue her passion for the Social-Natural sciences interaction through a Master of Science in Forestry program at NC State.

ACKNOWLEDGMENTS

Advisor: Dr. Bardon

Committee members: Dr. Dasmohapatra, Dr. Hazel

Administrative help: Linda Judge, Sarah Slover

Scantron compilation: Susan Ennis

Bulk mailing at Metro Productions: Clara Underwood

UNC-Chapel Hill for scanning services: June Williams

Undergraduate advisors: Dr. Susan Amato-Henderson, Dr. Kathy Halvorsen

Thank you to my loving parents, family and friends who have supported my dreams.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

Recent federal energy policy has required increases in production for various alternative energy sources. The Energy Policy Act (2005) introduced The Renewable Fuel Standard, which set standards for biofuel production through tax exemptions. A number of other federal energy policies have been enacted in the last fifteen years targeting woody biomass production (Susaeta *et al* 2012). In the case of cellulosic ethanol - an end product of woody bioenergy - shifted the alternative energy focus away from first-generation (corn) ethanol, partly due to debate over "food vs. fuel." Cellulosic ethanol, although still in the early stages, has the potential to decrease the usage of traditional energy sources, while benefitting non-industrial private forest (NIPF) landowners who own forestland.

With an increasing need for sustainable alternative energy sources, NIPF landowners in the southeast are excellent candidates for social-forest research on bioenergy topics. The southeastern United States holds a substantial amount of forestland, in addition to a number of bioenergy facilities. The southern United States encompasses 156,652,000 acres of forestland, and is home to 4,945,000 NIPF landowners (Butler 2008). To meet federal energy needs, an understanding of NIPF landowners, specifically in the southeastern United States is essential (Joshi and Mehmood 2011). NIPF landowners are defined as: "Families and individuals who own forestland and corporations and other private groups that own forestland, but do not own and operate a primary wood-processing facility. This group is a subset of private forest owners" (Butler 2008).

While NIPF landowners are succinctly defined, categorizing their attitudes, perceptions and behaviors has proven to be very difficult. Prior to the National Woodland

Owner Survey (NWOS), national surveys were sent to private forest landowners in an attempt to understand the factors that impact the use and management of their forestland (Birch *et al* 1982, Birch *et al* 1993). These surveys produced large demographic categorizations of forest landowners, which has served as the basis for a large number of more specific surveys. The authors have shown that forest landowner trends across the United States exist at the regional and state level.

Forest landowners tend to have higher education and income levels than the general public on a national scale. Approximately 30% of forest landowners have at least a bachelor's degree, and nearly 20% have an annual income of $100,000 (Butler 2008). The national average for forested acres of NIPF landowners is 25 acres. The southeastern average is slightly higher; North Carolina has a less than 50-acre average, whereas Virginia, Mississippi and Alabama have tracts that average between 50 and 100 acres. The most common acquisition type is purchasing, while inheritance is also relatively common. Almost half (40%) of forest landowners have owned their property for more than 25 years (Butler 2008). Additionally, 50% of respondents in the 2006 NWOS reported aesthetic, privacy and family legacy as the most important reasons for forest landownership. Similarly, 50% of these respondents also reported land investment as the top financial objective. Approximately 75% of NIPF landowners reside on or within one mile of their forestland. Most forest landowners do not participate in assistance programs or forest certification. Only 4% of forest landowners have a written forest management plan, and the most common sources of information are state forest agencies and private forest consultants (Butler 2008). It is evident that a deeper understanding of NIPF landowner perceptions of and attitudes toward the

bioenergy life cycle is crucial in addressing issues surrounding bioenergy production and feasibility.

Previous social science research has focused solely on attitudes, perceptions, willingness to supply, social networks and decision-making (Delshad *et al* 2010, Delshad *et al* 2013, Gruchy *et al* 2012, Joshi, O. 2013, Knoot, T. 2011, Leitch, Z. 2013). Similarly, little progress has been made in understanding NIPF landowner perceptions of and attitudes towards bioenergy facilities in proximity to their forestland. An understanding of these cognitions will allow for proper outreach, education and assistance to forest landowners seeking information or assistance in bioenergy harvesting.

To effectively measure forest landowner perceptions and attitudes towards bioenergy, ownership reasons and land management objectives must be included in assessment. NIPF landowners have a wide range of ownership reasons and land management objectives. Aesthetic, economic and recreational reasons are cited as the main reasons for national forest landownership (Butler 2008). Forest landowner networks have also been recognized as a factor in cognitions such as attitudes and perceptions, as well as management strategies and behaviors (Knoot *et al* 2011). It is essential to not only ask what information forest landowners are receiving, but also from where, from whom and what is the level of the relationship between these individuals? Results from an analysis with a combination of social influence factors will produce results that have not previously been reported. In assessing a combination of factors across the southeastern United States, we can continue to draw conclusions on various psychosocial aspects of NIPF landowners and bioenergy harvesting potential.

A Social Life Cycle Analysis (SLCA) was utilized to study the perceived environmental and economic impacts as well as social influences that impact the perception of the two bioenergy facilities in the surrounding area. A SLCA is the social adaptation of an Environmental Life Cycle Analysis (ELCA). A SLCA utilizes qualitative indicators in attempt to understand the social impacts of a given product throughout the life cycle (Dreyer *et al* 2006). Further, a SLCA measures various impacts on individuals and attempts to improve social conditions for involved stakeholders (Dreyer *et al* 2006, Jorgenson 2010). The overall goal of conducting a SLCA is to promote the improvement of social conditions for stakeholders (users or workers) and the socio-economic aspects of a products performance throughout the life cycle for all stakeholders involved (Jorgenson 2010). For a SLCA to be valid, it should assess the social consequences of a decision and be practical in decision-making strategies (Jorgenson 2010). Further, a SLCA requires site-specific data collection, to ensure minimum framing effects and bias are present in respondent answers (Delshad *et al* 2010, Delshad *et al* 2013). Data collection for a SLCA is site specific, thus the impacts measured in a SLCA are also site-specific (Efroymson *et al* 2012, Dreyer *et al* 2006).

Previous SLCA work focused on forming socioeconomic and environmental indicators for current and future work (Dale *et al* 2013a, Dale *et al* 2013b). The authors analyzed the environmental and socioeconomic indicators for assessing the sustainability of eucalyptus as a bioenergy feedstock. The authors present baseline indicators for the sustainability of eucalyptus and how this can be measured at the regional level (Dale *et al* 2013b). The indicators utilized for the SLCA in this study were adapted from the previous work by Dale *et al* (2013a, 2013b). A recent study reported the need for additional case

studies surrounding Social Life Cycle Analyses to help establish a set of social indicators (Griebhammer 2006). Previous SLCA work has utilized a mixture of environmental, economic and social indicators. The social indicators in previous work were broad in context and ambiguous in practice (Mbowha *et al*, Dale *et al* 2013a, Dale *et al* 2013b). In addition to the need for case studies focusing on forming social indicators (Griebhammer 2006) there is a need to understand beyond broad categories of NIPF landowners and their views towards bioenergy. The complexity of NIPF landowners, the lack of a deeper understanding of their cognitions and social norms that revolve around bioenergy production in the southeast led to the framework and methodology utilized in this project.

This project conducted a SLCA, consisting of surveys distributed to NIPF landowners surrounding two biomass facilities: Enviva (pellet mill in Ahoskie, NC), and KiOR (biofuel facility in Columbus, MS). Utilizing two groups of NIPF landowners in different regions of the southeastern United States allows a comparison of demographics while maintaining the ability to generalize to the southeastern population. Previous forest landowner research on biomass/fuel production has focused on general opinions of the process and product; leaving a substantial gap of knowledge on forest landowner perceptions and opinions of such facilities specific to their region (Delshad *et al* 2010, Galadima *et al* 2011). This project aims to fill this gap by comparing forest landowner perceptions, attitudes and beliefs about their local biomass facility, national biomass production, social norms and networks that influence their attitudes and beliefs and address how these two groups coincide with the success or failure of the local facility. The two samples of NIPF landowners were chosen based on the potential of being highly impacted by the biomass facilities, due to forestland in proximity to the facility. These impacts can be seen at the social, economic and environmental level; the

SLCA designed for this project measures these impacts across both groups of NIPF landowners within each study site.

The two study sites, Enviva and KiOR (bioenergy facilities) were selected due to location in the Southeastern United States, along with vastly different levels of success in the bioenergy industry. In addition to the presence of bioenergy facilities, 3 of the 4 states included in this study have significant percentages in relation to forest landownership and acreage (Butler 2008). North Carolina (13.9 million acres), Virginia (12.2 million acres), Alabama (17.7 million acres) and Mississippi (15.3 million acres) are states with significant acreage of private forestland. Furthermore, North Carolina is 1 of 5 states having the greatest number of private forest landowners, with more than 500,000. Alabama is 1 of 7 states with the highest percentage of private forest ownership, totaling over 90% in the state (Butler 2008). Mississippi and Virginia also have a significant number of NIPF landowners with 410,000 in Virginia and 370,000 in Mississippi. Collectively, the 4 states in this study are home to 1,717,000 NIPF landowners who own 59,330,000 acres of forestland (Butler 2008).

Established in 2004, Enviva produces wood pellets to be utilized as feedstock for energy production on an industrial scale. It supplies processed woody biomass in both domestic and international markets and is reported to be the South's largest exporter of wood pellets, exporting pellets primarily to Europe to produce electricity. Enviva has 5 pellet production facilities in Florida, Mississippi, and North Carolina. This study focuses on the facility in Ahoskie, North Carolina. Enviva-Ahoskie, was announced in December 2010 and began pellet manufacturing in November 2011. Enviva-Ahoskie has an annual production capacity of 385,809 dry tons (350,000 dry metric tons per year). Enviva also has another facility located within this study site, in Southampton County, Virginia with an annual

production capacity of 562,179 dry tons (510,000 metric tons per year) and employs over 70 full-time positions. Enviva facilities have a fiber sourcing standard through Sustainable Forestry Initiative (SFI) and a chain-of-custody certification through the Forest Stewardship Council (FSC). Enviva displays success through sustainable forest practices, feedstock in 2 regions of the southeast across 4 states, 2 port facilities, state of the art storage silos and a substantial production rate.

KiOR was constructed in 2012 and started shipping cellulosic fuels in early 2013. KiOR had many production aspects unique to alternative fuels. First, KiOR produced a high-value hydrocarbon based oil from biomass, rather than a corn based ethanol product. This technology mimicked the natural processes that create oil, which reduced this process to seconds. KiOR's aim was to produce a drop-in fuel that could be used as a gasoline or diesel blend, lessening the consumption of fossil fuels. The facility's primary feedstock was southern yellow pine in which it utilized 500 dry tons per day (453.6 dry metric tons per day) of biomass for production of crude oil. Nearly 90% of the crude oil was used as transportation fuel. KiOR also produced 90% of its own power. The company filed for Chapter 11 Bankruptcy Protection on November 9, 2014 and has since closed the facility. Prior to closing the facility, KiOR produced 13,000 gallons per day of crude oil and had 100 full-time and contract employees who operated the plant. The facility was designed to produce over 13 million gallons of renewable fuel annually. Since KiOR filed for bankruptcy, there has been negative press about the facility and the lawsuit brought by the state of Mississippi against the owners of KiOR for misleading the state into loaning the company over 75 million dollars.

2. Current Research

2.1 Psychosocial Aspects of Bioenergy

When analyzing behavior, there are many factors that affect individual and collective behaviors. Impacts from perceived norms and individual attitudes have been shown to impact individual behaviors, the former having the potential to impact the latter. Wegener and Kelly (2008) found in a study on the adoption of bioenergy technology (flexible fuel vehicles) that individual attitudes provide insight on the individual evaluation of an object, whereas social norms provide insight on a collective evaluation of that same object. Results from the authors show that to understand the likelihood an individual will behave in a supportive manner (using this vehicle) depends on their attitudes of using this technology, as well as social norms created by other individuals in their environment (Wegener and Kelly 2008).

Leitch *et al* (2013) found that perceived norms, respondent attitudes and control had significant impacts on intention to supply biomass feedstock. The researchers utilized the Theory of Planned Behavior, which states "To perform a specific behavior is the best predictor of future behavior and that intent is a function of an individual's attitude, subjective norms and perceived behavioral control" (Leitch *et al* 2013). Approximately 67% of respondents intended to include energy wood for bioenergy into their future harvests. Results from the study indicate attitude was the best predictor of intention to harvest. The only significant difference reported by the researchers was between inclusion of bioenergy information and proclaimed prior knowledge of the subject (Leitch *et al* 2013). The researchers recognized that norms can positively influence the intent of family forest landowners to supply feedstock.

2.2 Case Studies: Willingness to Supply and Information Seeking Behavior

Approximately 50% of the European Union's forestland is under private ownership, which is similar to that of the United States. Many of the European Union members also have legislation similar to the United States related to bioenergy and increase renewable resource utilization (Blennow *et al* 2014). Results from a study on 800 private forest landowners in Sweden, Germany and Portugal examined the attitudes and motivations towards supplying feedstock for bioenergy. Collectively, only 10% expressed a strongly positive attitude (Response: Most likely that I would convert to production of woody biomass for energy generation) or a weakly positive attitude (Response: Likely that I would convert to production of woody biomass for energy production) in favor of land conversion towards woody biomass production, even if this production involved a higher financial return. (Blennow *et al* 2014). From these results, authors concluded that European forest owners' willingness to supply feedstock for woody biomass production cannot solely be explained by price and market changes, thus, demonstrating the need for research to address other aspects of forest landowner willingness to supply woody biomass.

In a study of the Belgium public and their perceptions on bioenergy, Velde *et al* (2011) examined the behaviors involved in information seeking, such as preferences for certain information channels and their trust in these information sources. The researchers asked respondents to state the extent they sought out information on biofuels, assessed what sources of information the respondents preferred, as well as where they obtained information from in the past (Velde *et al* 2011). The authors found that 86% of respondents to some extent sought out information about biofuels. The main inquiries were made on tax

advantages/disadvantages and environmental impacts of biofuels. Respondents perceive scientists, environmental and consumer organizations and the government as the most trustworthy sources of information. Slightly less was word of mouth, with journalists and the industry are perceived as neutral or slightly untrustworthy.

2.3 The Role of Social Networks in Timber Harvesting

An exploratory study conducted in Wisconsin utilized social network analysis to assess how social networks and norms influence harvesting behavior. This exploratory study utilized an egocentric approach to examine the networks that forest landowners consult when planning to conduct a timber harvest. Egocentric networks include the individual being assessed, in addition to the peers and experts they are connected with (Marsden 1990). Forest landowners gather information about forest management directly through interaction, or indirectly through mailings and publications from these peers (Gass *et* al 2009). Similarly, Hujala *et al* (2007) and Hujala and Tikkanen (2008) found that forest landowners with varying decision-making strategies also vary in their preference for certain opinions and sources.

Forest landowners consider information accessibility and usefulness, source expertise and trustworthiness as well as similarity to others when assessing sources of information (Case 2007). Since trust in an information source can influence individual decisions, the most trusted sources are more likely to influence their decisions (Velde *et al* 2011). Interviewees were asked to identify the number of individuals they consulted, very important persons (VIP's), and frequency of contact with VIP's. To assess the level and number of qualities each VIP held, a Likert scale question was asked for each of the 5 qualities (Knoot and

Rickenbach 2011). Results from this study showed a mean network size of 4.1 (range 1-9), and a substantially smaller mean number of very important persons (VIP) network of 1.9 (range 0-5). A substantial difference was shown in the number of interviewees who identified family, friends, neighbors and peers as part of their network (77%) compared to their VIP list (39%). Similarly, the VIP's had more positive rankings in assessing the 5 qualities compared to peers in their network. If experts are contacted or utilized in the harvest, forest landowners are more likely to perceive the harvest outcomes in a positive way. Results from this study also show a connection between forest landowner involvement in tax-incentive programs, social interactions and timber harvesting experiences (Knoot and Rickenbach 2011).

2.4 Biofuel Producing Communities

There is a strong need to explore the impacts specific biofuel producing communities face, and how they perceive as well as experience the potential and danger of the biofuel industry (Selfa *et al* 2011). The majority of research conducted on community impacts from biofuel production have focused on developing countries, while very little research has focused on industrialized communities. A study done by Selfa *et al* (2011) explored the community perceptions on biofuels production through case studies utilizing individual and focus group interviews as well as community surveys done in 2 Midwestern states. Results showed that 1/3 of respondents stated the plant was "very important" to their local community, with some variation between study sites. Less than 10% of respondents stated the plant was not helping with poverty reduction in their local area. Although it was producing jobs for local residents, the jobs were not well paying. Only 17% of respondents in Kansas and 19% in Iowa stated "the benefits greatly outweigh the costs." Approximately

22% of respondents in Kansas, and 24% in Iowa stated "the benefits moderately outweigh the costs." Nearly 40% of respondents in Kansas and 36% in Iowa stated "the benefits and costs are about equal" in regards to the ethanol plant (Selfa *et al* 2011). When looking at the perceptions of community impacts, this study also reported that 69% of respondents in Kansas and 55% in Iowa stated the plant "produced noticeable odors." Approximately 30% of respondents in Kansas and Iowa perceived an increase in air pollution due to the ethanol plant. Around 44% in Kansas and 35% in Iowa perceived an "increase in traffic congestion." Overall, only 11% of Kansas respondents and 12% of Iowa respondents felt there was "a decrease in the overall quality of the environment" (Selfa *et al* 2011). The respondents were asked about the overall public opinion towards the ethanol plant. Nearly half (46%) of respondents in all study sites felt the current public opinion of the ethanol plant was positive, whereas 22% felt the opinion was negative, 13% felt it was neutral and 18% did not know.

3. Study Objective and Hypotheses

3.1 Study Objective

To better understand if normative social influence and/or success level of a proximal bioenergy facility impacts NIPF perceptions, attitudes and forest management behaviors related to bioenergy.

3.2 Hypotheses

H_o: The success level of the proximal facility will not impact NIPF landowner perceptions of the socio-economic and environmental impacts of a biomass facility, opinions on bioenergy production, related management behaviors and belief about other forest landowner opinions.

H_a: The success level of the proximal facility will impact NIPF landowner perceptions of the socio-economic and environmental impacts of a biomass facility, opinions on bioenergy production and belief about other forest landowners opinions.

H_o: Normative Social Influence will not impact NIPF forest landowner perceptions, beliefs and related management behaviors. NIPF landowner perceptions, beliefs and related management behaviors will not align with the perceived bioenergy norms within the NIPF and local community.

H_a: Normative Social Influence will impact NIPF landowner perceptions, beliefs and related management behaviors. NIPF landowner perceptions, beliefs and related management behaviors will align with the perceived bioenergy norms within the NIPF and local community.

4. Materials and Methods

4.1 Study Area

To conduct the SLCA and measure the perceived impacts of NIPF landowners from bioenergy facilities, data were collected from a random sample of NIPF landowners across 49 counties and 4 states surrounding 2 biofuel facilities, Enviva and KiOR. Each facility had

2 states that fell into the 60-mile procurement radius (based on driving distance); Enviva included North Carolina and Virginia (Figure 1), and KiOR included Mississippi and Alabama (Figure 2). There were 26 counties that were within the 60-mile procurement area for Enviva (18 in North Carolina, 8 in Virginia) and 23 counties that were within the 60-mile procurement area for KiOR (16 in Mississippi, 7 in Alabama). Collectively, the 4 states in this study are home to 1,717,000 NIPF landowners who own 59,330,000 acres of forestland.

4.2 Data Collection

County property tax data was gathered to develop a sample population for the study from each of the counties within the procurement area of each facility. Approximately 125 forest landowners who owned 20 or more acres of forestland were randomly selected from each county tax record. The 20-acre requirement stems from the likelihood that forest landowners with 20 or more acres of forestland are more likely to consider timber management. This allows for controlling for actively managing NIPF landowners within the study. This assumption is in line with many state's property tax programs, such as the North Carolina Present Use Value Program. In many states, 20 is the minimum number for timber acres when being considered for tax exemptions/reduced tax rates for actively managing private forestland. A previous study showed that as property size increases, the percentage of owners who say timber production is either important/very important also increases, showing importance in targeting NIPF landowners with larger tracts (Butler 2004).

A few counties had to be excluded due to issues with obtaining forest landowner data. The excluded counties were Calhoun, MS; Marion, AL and Franklin, VA. Only 2 counties had a limited forest landowner selection due to smaller county sizes or counties having

substantially less forestland. Counties with less than 125 forest landowners randomly selected were Portsmouth, VA and Camden, NC. The final number of forest landowners to be included in the sample population was 5,286.

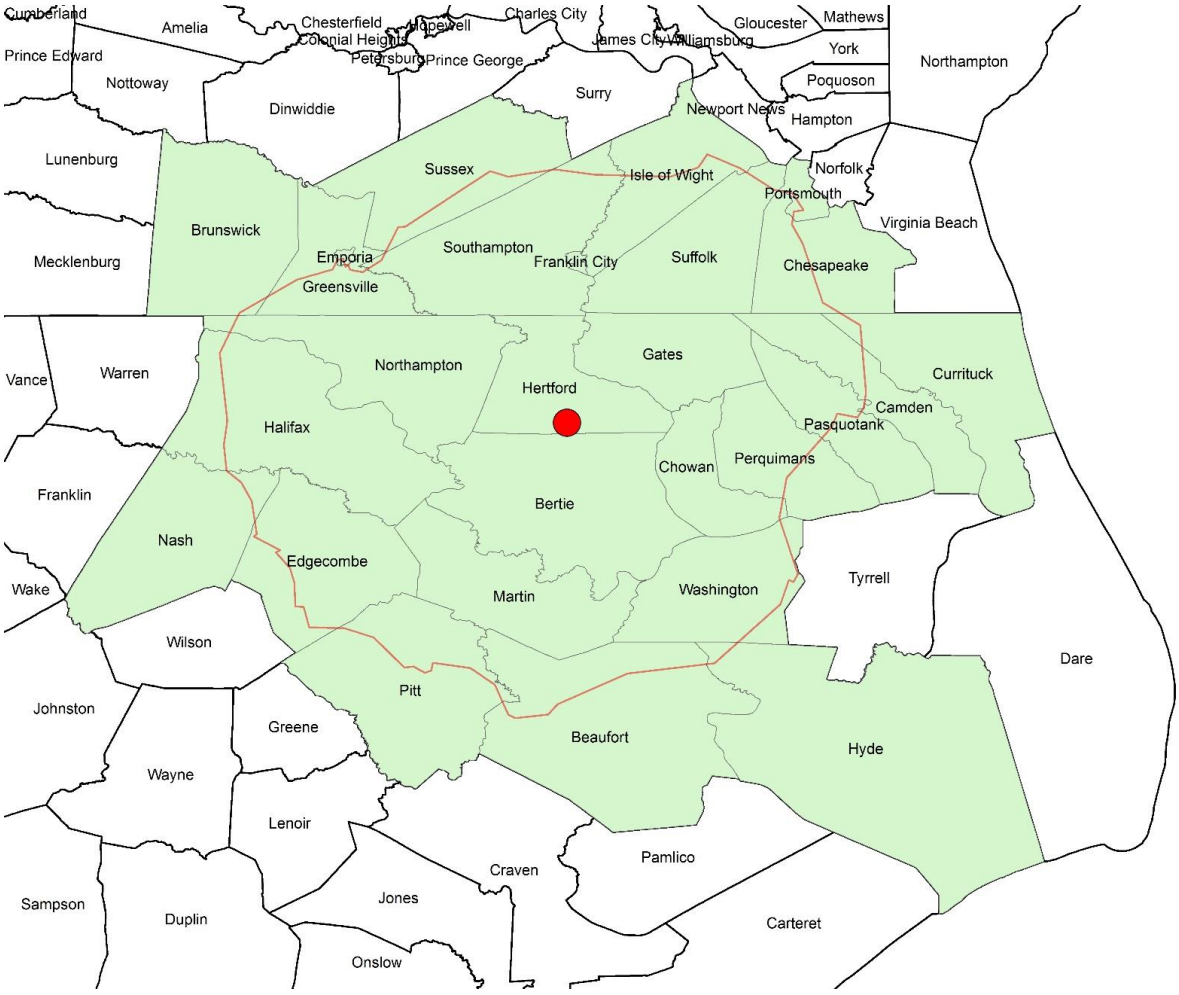

Figure 1. Eighteen counties in North Carolina and eight in Virginia that are within 60-mile travel distance of the Enviva pellet manufacturing facility in Ahoskie, North Carolina.

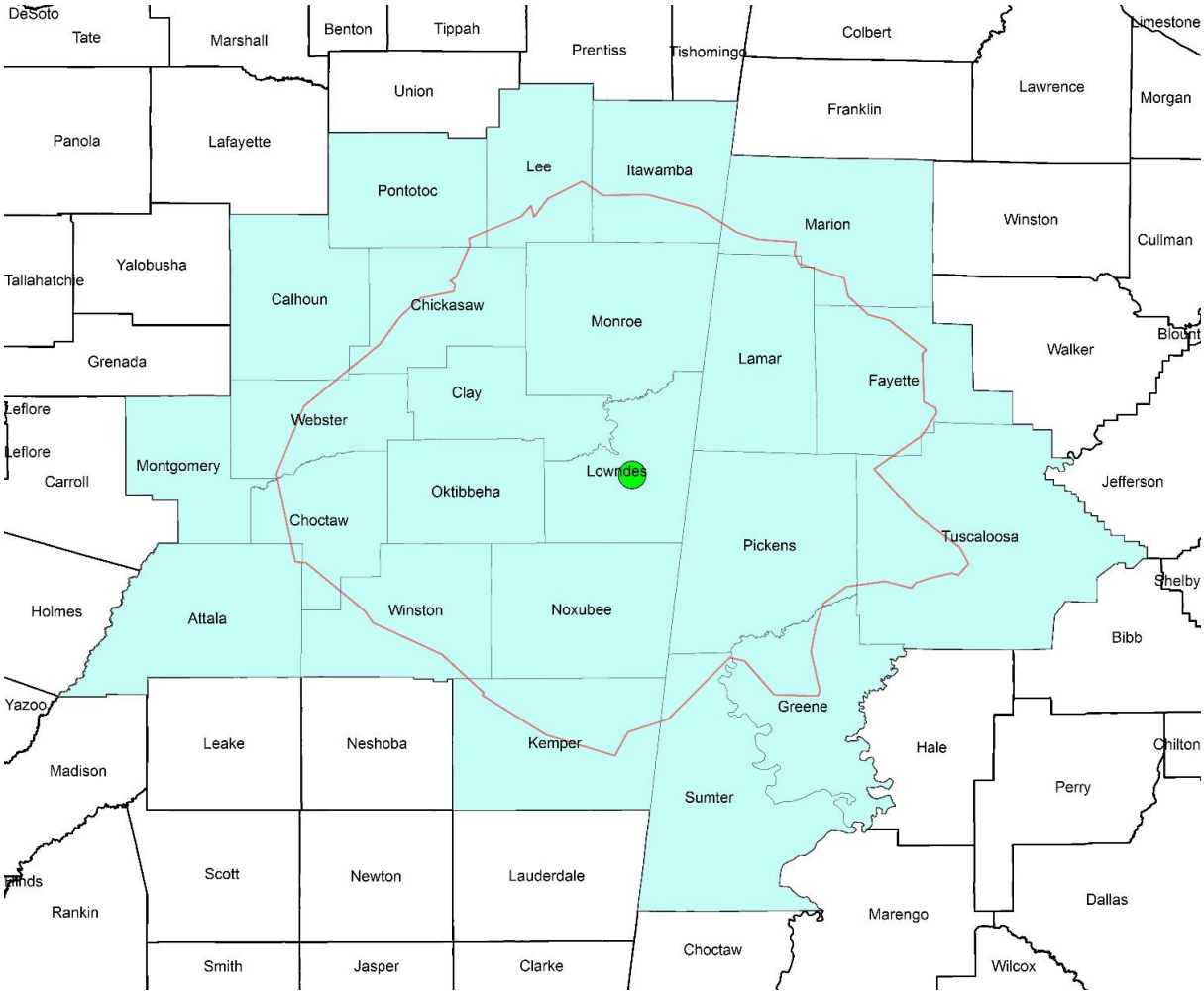

Figure 2. Sixteen counties in Mississippi and seven in Alabama that are within 60-mil travel distance of the KiOR biofuels manufacturing facility in Columbus, Mississippi

4.3 Survey Design

The survey design was adapted utilizing Dillman's Tailored Design Method for Internet, Mail and Mixed Mode Surveys (Dillman 2009). A recent study indicated that utilizing and altering Dillman's survey methodology produced an extremely high response rate (Clendenning 2013). In addition, demographic questions were at the end of the survey due to recent findings on response rate and demographic question placement. Demographic questions placed at the end of a survey can have a number of positive impacts on response

rate and framing effects (Giles *et al* 1978). First, respondents may be more likely to return a completed survey when demographic questions are at the end due to the time they have already spent on the survey. Second, the responses to agreement and opinion-based questions are less biased when respondents do not feel the demographics are first and extremely important (Giles *et al* 1978). Finally, this survey adhered to the authors' suggestion that demographic questions utilize answer categories instead of specific responses to increase survey completion and potential response rate.

To further increase response rate, the cover letter included: an appeal to a sense of social responsibility, an opportunity to receive a tangible reward rewards (Lowe's gift card), a survey response date, ease of response (golf pencil and pre-paid return postage), common language, legitimate sponsorship (NCSU), assurance of confidentiality and information security, and presenting the importance with survey mailing personalization. (Mowen and Cialdini 1980, Groves *et al* 1992).

The categories, indicators and units of the SLCA were the tools utilized to prove or disprove the study hypotheses. Survey questions were formed based on how the units could be presented in a question to trigger a response based on the unit itself. While ordering the survey, a conversation style order was chosen to ensure the questions from each indicator were in a comprehensive order. A substantial number of factors were considered when forming each question in the forest landowner survey, based on previous research (Dillman 2009). A considerable number of closed-ended questions were included for ease of answering and to increase the chances of survey completion. In addition, the 2013 National Woodland Owner Survey (NWOS) was consulted when forming questions for the emotional investment category. Survey questions were 'balanced' to ensure there were an equal number

of positive and negatively worded questions. Survey questions were reviewed by a committee of faculty and extension specialists who have experience in surveying forest landowners.

The final survey included 82 questions divided up into 10 categories. The first category covered demographic and ownership characteristics and is common in many social studies. It is important to know the demographic profile of the sample so that it can be compared to the population targeted for the study. Participation in certification and assistance programs are the second section of questions within the survey. This section was utilized to determine how much landowners seek out assistance as well as certification programs. The third section was used to determine the level of forest landowner involvement with the bioenergy facility. Since this is a study done on forest landowners within a certain radius of a bioenergy facility, the level of involvement is important in determining how their perceptions of said facility are gained. The determination of active vs. passive management strategies was the fourth category of questions. Active vs. passive management implies the level of landowner involvement with their property. Forest landowner involvement can be directly related to their level of knowledge on the timber markets that are available within their area. The fifth category of questions dealt with the amount of information forest landowners have sought out or received about the bioenergy facility in their area. Level of knowledge about the bioenergy facility and willingness to participate in the market can be attributed to the amount of information forest landowners seek out or receive on the facility. Bioenergy agreement statements were the sixth category of questions. These questions assessed forest landowners opinions on how biomass production might impact the local economy, others willingness to participate, overall impact on the community, national security, and national

energy needs. The seventh, eighth, and ninth categories involved assessing forest landowner perceptions on environmental and economic impacts, wildlife and site quality impacts, and importance of sustainable harvesting. Based on previous literature, these concepts are key for forest landowner participation in timber markets, in addition to the importance for meeting the several legal regulations placed on forest management strategies. The final category of questions was aimed at determining landowner dependence on income-based management strategies, and if biomass harvesting would fit in their income based management profile.

The questions within the categories were divided by the type of scale used in the response choices. These types include numerical, Likert scale, closed ended categorical, yes vs. no and continuous response options. An example of the Likert scale response choices ranged from: 1=Strongly Disagree, to 5=Strongly Agree with 3=Don't care/neutral. The response choices were not in continuous order, in an attempt to avoid respondents answering the same answer choice for every question (filling in bubbles in a vertical line). In addition, the "Don't care/Neutral" and "Don't know" responses were at the end of the choice list.

The final survey was mailed to the sample population in February 2015. The survey package included a golf pencil, cover letter, Scantron™ survey and pre-paid return postage envelope. The cover letter stated the survey goal, and assured respondents the responses were voluntary and confidential. No reminder card was sent after the initial survey due to the number of returned surveys statistically representing the population of forest landowners. A sample size of 384 statistically represents a population of one million people (Krejcie and Morgan 1970). In this study, 776 surveys were returned for a final response rate of 14.7%.

4.4 Social Life Cycle Analysis Framework

The framework utilized in this SLCA has been adapted from *Environmental and Socioeconomic Indicators for Bioenergy Sustainability as Applied to Eucalyptus* (Dale *et al* 2013b) and *Indicators for assessing socioeconomic sustainability of bioenergy systems: A short list of practical measures* (Dale *et al* 2013a) (Table 1). It is based on a portion of Dale's existing indicator framework with 3 additional categories; emotional investment, ecological/recreational purposes and peer influence/outside information (Table 1).

Table 1. Social Life Cycle Analysis Framework with Corresponding Indicators and Units to Analyze Social Impacts of Bioenergy Manufacturing Facilities Located in North Carolina and Mississippi

Category	**Indicator**	**Units**
Social well being	Income from land	Income increase from supplying feedstock
	Increase in acreage	Buying additional acres
	Opinion on Environmental well being	Overall impact on (community) environment
Energy security	Belief in bioenergy contribution	Belief in bioenergy at local & national scale
External trade	Belief in bioenergy impact	Local & national production will impact petroleum imports
Profitability	Long term supply (contract)	Presence/absence of supply contracts or guarantee
Resource conservation	Desire to harvest forest/agricultural land sustainably	Presence of management plan BMPs implemented
	Utilizing logging slash	Used in bioenergy production or saved for wildlife
	Change in forest productivity	Increase/decrease in acres of usable land

Table 1. Continued

Social acceptability	Public opinion	Percent favorable opinion
	Supply willingness	Willing or not willing, have not considered or will consider supplying
	Positive opinion about biomass production	Belief that biomass production is a worthwhile investment
	Community benefit	Benefits (overall) more than hurts the community
	Sharing support with community	Believe others support biomass production
Emotional investment	Reason for owning land	Personal vs. economic reasons
	Level of management	Spectrum: Active to passive
	Land transaction	Intent to pass down vs. selling
Recreational impacts	Documented wildlife disturbances	Increase/decrease in wildlife populations
	(Recreational) holding capacity	Increased income used for recreational opportunity
Peer influence/outside information	Information seeking behavior	Information sought out & on what topics?
		Sources of information
		Engaged in conversation
		Overheard conversation

Table 2 presents the survey questions (units) used for each indicator in each of the SLCA categories. Each indicator had at least 1 corresponding survey question. When compiling the questions for the SLCA, questions were selected based on keywords in the question and the response choices. For instance, the income from land indicator in the social well-being category had 5 survey questions. The questions and answer choices all had key words that revealed if the units were present and in what direction (positive, negative or neutral). The survey question selected to measure income from land was “I am willing to sell

trees to produce bioenergy if I can increase my income" based on the keywords in the question. Other questions were not selected due to a smaller number of key words tying the survey question to the unit for each indicator and category.

Table 2. Social Life Cycle Analysis Framework and Corresponding Survey Questions to Analyze Social Impacts of Bioenergy Manufacturing Facilities Located in North Carolina and Mississippi

Category	**Indicator**	**Survey Questions or Statements**
Social well being	Income from land	I am willing to sell trees for feedstock to produce bioenergy if I can increase my income.
	Increase in acreage	Have you purchased more forestland due to the establishment of the bioenergy facility?
	Opinion on Environmental well being	Which represents your opinion about the impact of the bioenergy facility on the local environment?
Energy security	Belief in bioenergy contribution	In my opinion, locally produced bioenergy feedstock from trees is not critical to national security.
External trade	Belief in bioenergy impact	In my opinion, using trees as a bioenergy feedstock is a better alternative than current sources of fossil fuels.
Profitability	Long term supply (contract)	Do you have a long-term supply contract with the bioenergy facility?

Table 2. Continued

Resource conservation	Desire to harvest forest/agricultural land sustainably	Best Management Practices are important to me in preserving my land.
	Utilizing logging slash	In my opinion, harvesting logging slash for bioenergy feedstock does not compromise forest health.
	Change in forest productivity	In my opinion, harvesting logging slash for bioenergy feedstock is not detrimental to the site's productivity.
Social acceptability	Public opinion	I believe most landowners in our area support biomass production.
	Supply willingness	Since the opening of the bioenergy facility, have you received income due to selling trees from your property to the bioenergy facility?
	Positive opinion about biomass production	Biomass production, overall has a positive impact on our community.
	Community benefit	In my opinion, the positive benefits will outweigh the negative impacts over the long-term.
	Sharing support with community	I believe local community members who don't own forestland do not support biomass production.
Emotional investment	Reason for owning land	What are the main reasons for owning your forestland?
	Level of management	Do you have a current forest management plan?
	Land transaction	How did you acquire the majority of your forestland?

Table 2. Continued

Recreational impacts	Documented wildlife disturbances	Have you noticed a change in wildlife populations on your land since the bioenergy facility was constructed?
	(Recreational) holding capacity	I am interested in maintenance of recreational use on my property.
Peer influence/outside information	Information seeking behavior	Have you sought out information on the local bioenergy facility?

Table 3 presents the rating scale used in the Social Life Cycle Analysis. The overall outcome of a given indicator is based on 2 interdependent factors, the percentage of respondents and the direction of the question. If a low percentage of forest landowners respond (0-29%) or have a low Likert-scale rating (1 to 2.5) in the direction of a positive question, the outcome is negative. Conversely, if a low percentage of forest landowners respond (0-29%) or have a low Likert-scale rating (1 to 2.5) in the direction of a negative question, the outcome is positive. A response between 30-65% or a Likert-scale rating of 2.6 to 3.5 in the direction of a positive or negative question represents a neutral outcome. If a high percentage of forest landowners respond (66% or more) or have a high Likert-scale rating (3.6 to 5) in the direction of a positive question, the outcome is positive. Conversely, if a high percentage of forest landowners respond (66% or more) or have a high Likert-scale rating (3.6 to 5) in the direction of a negative question, the outcome is negative.

Table 3. Rating Scale used to analyze the overall Outcomes of each Survey Question and Indicator in the Social Life Cycle Analysis

Percentage of Respondents	**Mean Likert Scale Response**	**Fraction Equivalent**	**Question Direction**	**Outcome**
0-29%	1 to 2.5	1/3	Positive	Negative
			Negative	Positive
30-65%	2.6 to 3.5	2/3	Positive	Neutral
			Negative	Neutral
66% or more	3.6 to 5	2/3 or more	Positive	Positive
			Negative	Negative

Table 4 presents the SLCA categories and the reasoning behind the inclusion, adaptation or addition of each category. These adaptations were made to the existing framework to address how forest landowners are impacted in areas that are less obvious or have not been addressed in previous research.

Table 4. Reasoning behind Categories in the Social Life Cycle Analysis and Prompts for Question Formation in the Survey

Category	**Reasoning**
Social Well being	Has the bioenergy facility changed landowners' financial situations? Do landowners see the facility impacting the environment?
Energy Security	Do landowners believe biomass production impacts national (energy) security? Is bioenergy seen as a 'good' alternative to fossil fuels?
External Trade	Do landowners believe bioenergy is a feasible long-term alternative? Do landowners believe utilizing bioenergy impacts climate change?
Profitability	Are management decisions greatly impacted by monetary gains?

Table 4. Continued

Resource Conservation	Are landowners concerned about sustainable harvesting practices? Do landowners need assurance of sustainable harvesting practices to supply biomass feedstock? Are landowners concerned about site productivity impacts from bioenergy harvesting?
Social Acceptability	Do landowners believe the public supports biomass production? Do landowners believe other landowners support biomass production? Do landowners believe biomass production is a worthwhile investment? Do landowners see production as an overall benefit or detriment to the community?
Emotional Investment	What are the main reasons for land ownership, and how do emotional ties impact harvesting decisions? Are the landowners active or passive forest managers? Are landowners planning to pass their land down or sell it (outside of family) in the future?
Recreational Impacts	Have landowners noticed a change in wildlife populations on their land? Have landowners noticed a change in wildlife populations within the study site? Would landowners increase recreation on their land if their income increased from harvesting biomass?
Peer influence/outside information	Are landowners seeking out information on the bioenergy facility? If so, information on what? What outlets do landowners use in seeking out information on forest related topics? Do landowners engage in discussion about the bioenergy facility? If so, is it positive, negative, a mix of both or neutral? Have landowners heard others discussing the bioenergy facility? If so, is it positive, negative, a mix of both or neutral?

4.5 Statistical Analysis

Initial statistical analysis was conducted in Microsoft Excel to determine the counts (n=x) and percentages for each category in each survey question. Means and standard deviations were then calculated for each Likert-scale agreement question. Demographic and ownership profiles were compiled to display characteristics of survey respondents. In addition, tables were compiled to show all related percentages for each category of questions (wildlife disturbances, incentive/assistance program participation, etc…). Once these tables were produced, the percentages, means and standard deviations between independent variables and dependent variables were calculated. All subsequent statistical analysis was performed in Statistical Package for the Social Sciences (SPSS).

Independent Samples T-tests were conducted to determine if there were significant differences in calculated means between two groups of individuals (active vs. passive managers, etc…). T-tests produce two analysis tables, Levene's Test for Equality of Variances and T-test for Equality of Means. Levene's Test assumes the variability between groups is equal. This test produces two values, the F value and its corresponding significance value. If the F value is large (greater than 1.0) and the significance value is below 0.05 (alpha level), the null hypothesis that variability between groups is equal is rejected. If there is a significant difference displayed in Levene's Test and if the two-tailed significance in the T-test for Equality of Means (equal variances not assumed) is less than the alpha level, there is a statistically significant difference in the two groups.

Correlations were first conducted to test for the relationship between perceived norms and forest landowner opinions. Preliminary correlations indicate if there is a relationship between two normally distributed variables. If there is a correlation between the two

variables and the Probability-Probability plot shows a linear relationship, a simple linear regression should be conducted to determine the strength of the relationship. Correlations and simple linear regressions were conducted to test the relationship between perceived norms and forest landowner opinions. Results from a simple linear regression will indicate whether or not there is a strong relationship between the two variables. The strength of this relationship is indicated by the R^2 value (closer to 100 is indicative of a strong relationship) in the ANOVA (Analysis of Variance) output.

5. Results

5.1 Survey Response Rate

A total of 5,286 forest landowners were contacted and 776 surveys were returned. Of the returned surveys, 111 forest landowners responded "No" to Question 1: 'Are you a current forest landowner?' and were not used in any of the analyses. A total of 665 surveys were used with a response rate of 12.6% in the overall analyses. Table 5 presents the state-by-state count and percentage of survey respondents. Approximately 52% of respondents own forestland in North Carolina (n=346) and 11.9% own forestland in Virginia (n=79) for a total of 63.9% (n=425) of respondents owning forestland in the Enviva study site. Approximately 17% of respondents own forestland in Mississippi (n=114) and 18.9% own forestland in Alabama (n=126) for a total of 36% (n=240) of respondents owning forestland in the KiOR study site.

Table 5. State-by-State Total Response Rate and Percentage of Total Responses

Response Rate (n=665)			
Study Site	**State**	**n**	**Percentage of Total**
Enviva	North Carolina	346	52.0%
	Virginia	79	11.9%
KiOR	Mississippi	114	17.1%
	Alabama	126	18.9%

It is difficult to diminish the effects of non-response bias in qualitative studies. Although these effects cannot be avoided, there are ways to test for non-response bias in a given data set. Non-respondents have been shown to have similar responses as late respondents. Independent Samples T-tests were conducted to test for significant differences between early (n=434) and late (n=232) respondents. A total of 27 variables were assessed, including: key bioenergy agreement statements, demographics, information seeking behavior, active vs. passive management and income-based management strategies. Only 1 significant difference was found between early and late respondents, the belief that most forest landowners in the local area support biomass production (Early mean=3.78, Late mean=3.52, p value=.04). No significant differences were found for the other 26 variables, indicating nonresponse bias is not a source of error in this study.

5.2 Demographic Profile

A combined demographic profile for respondents by site is presented in Table 6. Approximately 80% of respondents are male (Enviva 79%, KiOR 81.6%) and approximately 20% are female (Enviva 21%, KiOR 18.4). Collectively, 76% of respondents are over the age of 60 years (Enviva 76.1%, KiOR 76.9%), and roughly 93% are over the age of 50 years

(Enviva 93.5%, KiOR 92.2%). Nearly half of respondents have a bachelors or graduate degree (Enviva 51.3%, KiOR 50.7%). Approximately 15% of respondents have an annual household income between $25,000 and $50,000 (Enviva 14.9%, KiOR 16.4%). Nearly 30% of respondents have an annual household income between $50,000 and $100,000 (Enviva 25.3%, KiOR 31.8%). Approximately 30% of respondents have an annual income greater than $100,000 (Enviva 35.3%, KiOR 30.4%). Nearly 20% of respondents preferred not to report their household income (Enviva 21.3%, KiOR 18.2%).

Table 6. Combined and Study Site Specific Demographic Profile of Survey Respondents

	Study Site		
Gender	**Enviva (n=391)**	**KiOR (n=212)**	**Combined**
Male	79.0%	81.6%	79.9%
Female	21.0%	18.4%	20.1%
Age Class	**Enviva (n=402)**	**KiOR (n=216)**	**Combined**
20-29	0.2%	0%	0.2%
30-39	0.7%	1.9%	1.1%
40-49	5.5%	6.0%	5.7%
50-59	17.4%	15.3%	16.7%
60-69	33.6%	43.1%	36.9%
70-79	25.1%	22.2%	24.1%
80+	17.4%*	11.6%*	15.4%*
Education	**Enviva (n=404)**	**KiOR (n=215)**	**Combined**
High School	11.4%	9.3%	10.7%
High School graduate	11.4%	11.2%	11.3%
Some college	15.6%	20.0%	17.1%
Associate's degree	10.4%	8.8%	9.9%
Bachelor's degree	34.7%	22.3%	30.4%
Graduate or professional degree	16.6%*	28.4%	20.7%*

Note: Numbers in column may not add to 100% due to rounding*

Table 6. Continued

Household Income	Enviva (n=403)	KiOR (n=214)	Combined
Under $25,000	3.2%	3.3%	3.2%
$25,000 to less than $50,000	14.9%	16.4%	15.4%
$50,000 to less than $100,000	25.3%	31.8%	27.6%
$100,000 to less than $150,000	17.9%	14.5%	16.7%
Over $150,000	17.4%	15.9%	16.9%
Prefer not to answer	21.3%	18.2%*	20.3%*

Note: Numbers in column may not add to 100% due to rounding*

5.3 Ownership Profile

Table 7 presents the overall ownership profile of survey respondents and for each location separately. Although the request for county property tax records specified to only include forest landowners with 20 or more forested acres, 2.3% of respondents own between 1 and 9 acres (Enviva 3.4%, KiOR 0%). Similarly, 4% of respondents own between 10 and 19 acres (Enviva 5.4%, KiOR 1.4%). Approximately 20% of forest landowners report owning 20 to 49 acres (Enviva 21.1%, KiOR 19.5%), 18.3% own between 50 to 99 acres (Enviva 20.1%, KiOR 14.9%), 35% own between 100 and 499 acres (Enviva 32.4%, KiOR 40%), 7.4% own between 500 and 999 acres (Enviva 5.7%, KiOR 10.7%), 6.3% own 1,000 to 4,999 acres (Enviva 5.9%, KiOR 7%) and 6.1% report owning more than 5,000 acres (Enviva 5.9%, KiOR 6.5%). Approximately 43.1% of forest landowners report having forest with planted pine as the primary species (Enviva 43%, KiOR 43.3%). About 38.5% report forest with mixed hardwood and pine as the primary species (Enviva 39.1%, KiOR 37.3%),

and 11.8% state their forest as mainly natural pine (Enviva 13.9%, KiOR 7.5%). Natural hardwood forests are reported by 5.6% of forest landowners as their primary species (Enviva 3.7%, KiOR 9.5%). Less than 1% reported planted hardwood (Enviva 0%, KiOR 1%) or "other" (Enviva 0.2%, KiOR 1.5%) as the primary species on their forestland.

The majority of owners (61.2%) state they have sole ownership (Enviva 60.1%, KiOR 63.2%). Nearly 30% report their forestland is family owned (Enviva 29.6%, KiOR 30%), and only 4.5% indicate a partner ownership (Enviva 5%, KiOR 3.7%). Respondents were also asked to indicate how they acquired the majority of their forestland. Collectively, 97.5% of respondents either inherited (49.4%, Enviva 53.5%, KiOR 41.4%) or purchased (48.1%, Enviva 43.4%, KiOR 57.2%) their forestland. Only 1.9% received their forestland as a gift (Enviva 2.6%, KiOR 0.5%), and less than 1% responded "other" (Enviva 0.5%, KiOR 0.9%) as to how they acquired the majority of their forestland. Approximately 52.1% of forest landowners acquired their forestland from their parents or their spouse's parents (Enviva 56.4%, KiOR 44.1%). Approximately 3.2% of respondents acquired their forestland from their spouse (Enviva 4.2%, KiOR 1.5%), and 33.6% report their forestland coming from an individual outside of their or their spouse's families (Enviva 30.4%, KiOR 39.7%). Approximately 8.7% of respondents acquired their forestland from a family member other than their or their spouse's parents (Enviva 6.8%, KiOR 12.3%). Only 2.2% of respondents acquired their forestland from a business (Enviva 2.3%, KiOR 2%), and less than 1% of respondents acquired their forestland from a government agency (Enviva 0%, KiOR 0.5%).

Table 7. Combined and Study Site Specific Forest Ownership Profile of Survey Respondents

	Study Site		
Total Forested Acres	**Enviva (n=407)**	**KiOR (n=215)**	**Combined**
1 to 9	3.4%	0.0%	2.3%
10 to 19	5.4%	1.4%	4.0%
20 to 49	21.1%	19.5%	20.6%
50 to 99	20.1%	14.9%	18.3%
100 to 499	32.4%	40.0%	35.0%
500 to 999	5.7%	10.7%	7.4%
1,000 to 4,999	5.9%	7.0%	6.3%
5,000+	5.9%*	6.5%	6.1%
Primary type of species you grow on your forestland	**Enviva (n=402)**	**KiOR (n=201)**	**Combined**
Natural hardwood	3.7%	9.5%	5.6%
Natural pine	13.9%	7.5%	11.8%
Planted hardwood	0.0%	1.0%	0.3%
Planted pine	43.0%	43.3%	43.1%
Mixed hardwoods & pine	39.1%	37.3%	38.5%
Other	0.2%*	1.5%*	0.7%
Type of forestland ownership	**Enviva (n=341)**	**KiOR (n=190)**	**Combined**
Sole Ownership	60.1%	63.2%	61.2%
Family Owned	29.6%	30.0%	29.8%
Partnership	5.0%	3.7%	4.5%
Corporation	3.5%	1.1%	2.6%
Other	1.8%	2.1%*	1.9%
How did you acquire the majority of your forestland?	**Enviva (n=419)**	**KiOR (n=215)**	**Combined**
Purchased	43.4%	57.2%	48.1%
Inherited	53.5%	41.4%	49.4%
Received as a gift	2.6%	0.5%	1.9%
Other	0.5%	0.9%	0.6%

Table 7. Continued

From whom did you acquire your forestland?	Enviva (n=385)	KiOR (n=204)	Combined
My parents/spouse's parents	56.4%	44.1%	52.1%
My Spouse	4.2%	1.5%	3.2%
Another family member	6.8%	12.3%	8.7%
Other individual(s)	30.4%	39.7%	33.6%
A business	2.3%	2.0%	2.2%
Government agency	0%*	0.5%*	0.2%

Note: Numbers in column may not add to 100% due to rounding*

Respondents were asked to indicate the most important reasons in owning their forestland. Table 8 presents the main reasons forest landowners indicated for owning their forestland. Family legacy, the ability to pass their land down to children, was the most important reason to most respondents (mean=4.1). Respondents indicated investment as another main reason for owning forestland (mean=3.8), in addition to wildlife management (mean=3.4). Interestingly, most forest landowners indicated neutrality when income from timber sales (mean=3.3) and recreation (mean=2.9) were considered. Most forest landowners cited tax breaks (mean=2.2) and hunting lease (mean=2.1) as the least important reasons in owning forestland.

Table 8. Means and Standard Deviations for the Main Reasons for Forest Landownership

Reason for Owning Forestland (n=608)	**Mean**	**Std. Dev**
Family Legacy (e.g., pass down to children)	4.1	1.2
Investment (increase in land and/or timber value over time)	3.8	1.2
Wildlife management	3.4	1.3
Income from timber sales	3.3	1.5
Recreation (e.g., hiking, bird watching)	2.9	1.4
Tax breaks	2.2	1.2
Hunting lease	2.1	1.4
Other	2.7	1.8

Note: the scale used for the main ownership reasons is as follows: 1=Least Important, 2=Somewhat Important, 3=Neutral, 4=Important, and 5=Extremely Important. Other category includes: Hunting camp, other recreational activities and solitude/privacy.

An independent samples T-test was conducted to test for significant differences between ownership types (Sole, family) on key bioenergy statements. None of the other ownership types were tested due to the small sample size under each type. Results from the T-test failed to show significance (95% significance) between the two ownership types on key bioenergy statements.

A subsequent independent samples T-test was conducted to measure significance between land acquisition type on key bioenergy statements (95% significance) (Table 9). Results from this T-test indicates a significant difference in respondents who purchased their forestland (mean=3.80, sd=.94) and those who inherited their forestland (mean=3.55, sd=1.08) in the belief that most forest landowners in the local area support biomass production ($t(219.82)=2.03$, $p=.04$). A significant difference was also reported in respondents

who purchased their forestland (mean=3.89, sd=1.08) and those who inherited their forestland (mean 3.63, sd=1.02) in the opinion that positive benefits from biomass production will outweigh the negative impacts in the community (t(272.17)=2.12, p=.04). Results from another T-test indicates forest landowners who inherited their land (mean=1.30, sd=.46) were more likely than those who purchased their forestland (mean=1.21, sd=.41) to actively manage their land (t(529.36)=-2.25, p value=.02).

Table 9. T-test Results on Land Acquisition Type of Combined Respondents and Key Bioenergy Agreement Statements

	Land Acquisition (mean ratings)		**t**	**df**	**P Value**
Key Bioenergy Agreement Statement	**Purchased (n=304)**	**Inherited (n=313)**			
I believe most landowners in our area support biomass production	3.80 (sd=.94)	3.55 (sd=1.08)	2.03	219.82	.04
In my opinion, the positive benefits associated with biomass production for our community will outweigh the negative impacts it has created in our community over the long-term	3.89 (sd=1.08)	3.63 (sd=1.02)	2.12	272.17	.04
I (we) actively manage the land I (we) own	1.21 (sd=.41)	1.30 (sd=.46)	-2.25	529.36	.02

Note: the scale used is as follows: 1=Least Important, 2=Somewhat Important, 3=Neutral, 4=Important, and 5=Extremely Important.

An independent samples T-test was conducted to test the relationship between active level of management and the top reasons for forest landownership: Investment, income from timber sales, recreation, wildlife management and family legacy. This test indicates a significant difference in active managers (n=269, mean=3.92) and passive managers (n=276,

mean=3.40) who own their forestland mainly for investment purposes (p value=.00). Although this test failed to report statistically significant differences for the remaining ownership variables, it appears there are differences between active managers (mean=2.96) and passive managers (mean=2.77) who own their forestland mainly for recreational purposes. In addition, there are also differences in the means of active managers (mean=4.16) and passive managers (mean=3.94) that reported family legacy as an important ownership reason.

In this study 2 questions were used to determine a respondent's level of forest management. The first question asked if respondents currently had a management plan for their forestland. The second question asked respondents to indicate if they actively manage the forestland they currently own. For the second question, a definition of active management was provided. Active management was defined as having one or more of the following 6 listed activities conducted on their forestland: afforestation, chemical/mechanical management of weeds/undesirable vegetation, removing dead/diseased trees to improve stand quality, conducting thinning operations or protecting soil and water quality through Best Management Practices (BMP) implementation.

Table 10 presents the results of the active vs. passive forest management survey questions. The overall percentage of forest landowners who currently have a management plan (50.3%) varied only slightly from the percentage of forest landowners who did not currently have a management plan (49.7%). Approximately half of Enviva respondents (45.5%) and over half of KiOR respondents (52.7%) have a current forest management plan. In addition, 76.6% of Enviva respondents and 72.9% of KiOR respondents stated they actively manage their forestland. As shown in Table 10, nearly 70% of forest landowners

reported they actively manage the forestland they own, 24.1% said they did not actively manage their forestland, and 6.5% of respondents were unsure if they participated in active or passive management. Since BMP implementation was an example of active management, respondents were asked if BMP's were important to them in preserving their land. A substantial number (92.8%) of forest landowners responded "yes" to this question on BMP's.

Table 10. Combined Percentages of Enviva and KiOR Respondents on Forestland Management Level Survey Questions

Do you currently have a management plan for your forestland? (objective)	**Percentage of Respondents (n=587)**
Yes	50.3%
No	49.7%
I (we) actively manage the forestland I (we) own (subjective)	**Percentage of Respondents (n=617)**
Yes	69.2%
No	24.1%
Unsure	6.5%
Best Management Practices are important to me in preserving my land	**Percentage of Respondents (n=622)**
Yes	92.8%
No	1.3%
Unsure	5.9%

An overwhelming majority of respondents are not participating in forest certification, and only a small number of respondents are participating in financial assistance programs (Tables 11 and 12). Collectively, 17.8% of respondents currently have their forestland certified (9.9% have American Tree Farm certification, 4.1% have Forest Stewardship Council certification and 3.8% have Sustainable Forest Initiative certification on their

forestland) (Table 11). Collectively, 59.2% of respondents are participating in some type of financial assistance program (Table 12). Approximately 25% of respondents are participating in either Conservation Reserve Program (25.7%) or a Property Tax Incentive Program (24.4%). In comparison, only 8.6% of respondents are participating in Environmental Quality Incentives Program, and less than 1% are participating in Biomass Crop Assistance Program.

Table 11. Combined Percentages of Enviva and KiOR Respondents Participating in Forest Certification Programs

Type of Certification Program	**Percentage of Respondents Participating (n=106)**
American Tree Farm	9.9%
Forest Stewardship Council	4.1%
Sustainable Forest Initiative	3.8%

Table 12. Combined Percentages of Enviva and KiOR Respondents Participating in Forest Incentive Programs

Type of Incentive Program	**Percentage of Respondents Participating (n=364)**
Conservation Reserve Program	25.7%
Property Tax Incentive Program	24.4%
Environmental Quality Incentives Program	8.6%
Biomass Crop Assistance Program	0.5%

5.4 Bioenergy Agreement Statements

In this study, 12 key agreement statements on bioenergy were utilized to measure: forest landowner perceptions of environmental and economic impacts of bioenergy production, opinions on bioenergy and issues of national security/climate change, and the perceived opinions (normative social influence) of forest landowners as well as community members (Table 13). The highest agreement forest landowners had was the opinion that

forest landowners should consider supplying biomass feedstock (mean=3.8). On average, most forest landowners agreed that bioenergy produced from trees is more environmentally friendly (mean=3.7), and that local forest landowners support biomass production (mean=3.7). This shows a strong social influence on and from forest landowners, when considering the belief that forest landowners should consider supplying biomass feedstock and the belief that others (aside from the respondent) support biomass production. In addition, most respondents agreed that biomass production has an overall positive community impact (mean=3.7), and the positive benefits associated with biomass production will outweigh the negative impacts in their community over time (mean=3.7). Most respondents disagreed that biomass production was not a worthwhile investment for the local economy (mean=2.3), and there not being a community benefit due to the local biomass plant (mean=2.4).

Forest landowners had relatively neutral opinions when asked if locally produced bioenergy feedstock from trees was critical to national security (mean=3.2) and the belief that most local community members who don't own forestland do not support biomass production (mean=2.9). Respondents also showed overall neutral opinions towards climate change and national security questions, although they had relatively high agreement when asked if using trees as a bioenergy feedstock is a better alternative than current sources of fossil fuels (mean=3.6) and locally grown trees as a bioenergy feedstock is important in meeting national energy needs (mean=3.5).

Table 13. Means and Standard Deviations for Combined Enviva and KiOR Respondents on Key Bioenergy Agreement Statements

Key Bioenergy Agreement Statement	**Mean**	**Std. Dev**
In my opinion, landowners should consider supplying biomass feedstock	3.8	1.0
Compared to fossil fuels, bioenergy produced from trees is more environmentally friendly	3.7	1.1
In my opinion the positive benefits associated with biomass production for our community will outweigh the negative impacts it has created in our community over the long-term	3.7	1.0
I believe most landowners in our area support biomass production	3.7	1.0
Biomass production, overall, has a positive impact on our community	3.7	1.0
In my opinion, using trees as a bioenergy feedstock is a better alternative than current sources of fossil fuels	3.6	1.1
Using locally grown trees as a bioenergy feedstock is important in meeting our national energy needs	3.5	1.1
In my opinion, using trees as a bioenergy feedstock will not minimize the impacts of climate change	3.4	1.2
The bioenergy facility has had a positive economic impact on our community	3.4	1.1
In my opinion, locally produced bioenergy feedstock from trees is not critical to national security	3.2	1.2
I believe most local community members who don't own forestland do not support biomass production	2.9	1.1
I don't see a community benefit due to the local biomass plant	2.4	1.1
In my opinion, biomass production is not a worthwhile investment for the local economy	2.3	1.2

Note: the scale used is as follows: 1=Strongly Disagree, 2=Disagree, 3=Don’t care/neutral, 4=Agree, and 5=Strongly Agree.

An independent samples T-test (95% significance) was conducted to test the relationship between study sites (Enviva, n=148 and Kior, n=241) on relative agreement to 33 key survey questions. Forest landowners who did not provide a zip code for their

forestland were not included in site specific T-tests. Results of this T-test only indicated 1 statistically significant differences between study site and key survey questions (Table 14). Analysis indicated a significant difference in Enviva respondents (mean=3.50) and KiOR respondents (mean=3.73) in willingness to sell trees for bioenergy if their income would increase (t(510.35)=-3.01, p value=.00). No statistical significance was found in the other 32 variables, therefore, sites were combined for subsequent analyses. Although not statistically significant, Enviva respondents showed stronger agreement to the statement 'I believe most landowners in our area support biomass production' (mean=3.77) in comparison to KiOR respondents (mean=3.54). Conversely, KiOR respondents showed stronger agreement to the statement 'Using locally grown trees as a bioenergy feedstock is important in meeting our national energy needs' (mean=3.63) compared to Enviva respondents (mean=3.44).

Table 14. T-test Results on Study Site and Key Survey Questions

Key Survey Questions	**Site**	**Mean**	**t**	**df**	**P Value**
Using locally grown trees as a bioenergy feedstock is important in meeting our national energy needs	Enviva	3.44 (sd=1.91)	-1.67	311.48	.10
	KiOR	3.63 (sd=.98)			
I believe most landowners in our area support biomass production	Enviva	3.78 (sd=.89)	1.89	203.16	.06
	KiOR	3.54 (sd=1.08)			
I am willing to sell trees for feedstock to produce bioenergy if I can increase my income	Enviva	3.5 (sd=1.02)	-3.01	510.35	**.00**
	KiOR	3.73 (sd=.91)			

Table 14. Continued

If you heard people discussing the local bioenergy facility, how would you describe the overall discussion?	Enviva KiOR	2.15 (sd=1.20) 2.04 (sd=1.11)	0.50	97.79	.62
If my income increased from harvesting for the bioenergy facility, I would want to increase recreational use on my property	Enviva KiOR	2.23 (sd=.74) 2.22 (sd=.81)	0.09	393.16	.93
Is harvesting for bioenergy included in your management plan?	Enviva KiOR	1.86 (sd=.35) 1.9 (sd=.30)	-1.31	361.80	.19
For me to supply biomass feedstock, I would need assurance of sustainable harvesting practices	Enviva KiOR	1.53 (sd=.84) 1.43 (sd=.77)	1.47	483.25	.14

5.5 Active and Passive Forest Management

An independent samples T-test was performed to test the relationship between forest management activity level and key bioenergy agreement statements (Table 15). To measure the level of forest management activity, respondents were asked to answer Yes/No to the question 'I (we) actively manage the land I (we) own.' Respondents were provided with several examples of varying forest management activities to provide an analogous frame of reference to all respondents. Results from the T-test indicate significant differences (95% significance level) between active managers and passive managers on 2 bioenergy variables (Table 15). Variable 1: In my opinion, the positive benefits associated with biomass

production for our community will outweigh the negative impacts it has created in our community over the long-term (active mean=3.85, sd=.98; passive mean=3.35, sd=1.12; t(83.75)=3.17, p=.00). Variable 2: In my opinion, using trees as a bioenergy feedstock is a better alternative than current sources of fossil fuels (active mean=3.72, sd=1.02; passive mean=3.20, sd=1.14; t(118.86)=3.69, p=.00).

Table 15. T-test Results of Level of Forest Management Activity of Combined Survey Respondents and Key Bioenergy Statements

	Management Level (mean ratings)				
Key Bioenergy Agreement Statement	**Active (n=268)**	**Passive (n=80)**	**t**	**df**	**P Value**
In my opinion, the positive benefits associated with biomass production for our community will outweigh the negative impacts it has created in our community over the long-term	3.85 (sd=.98)	3.35 (sd=1.12)	3.17	83.75	.00
In my opinion, using trees as a bioenergy feedstock is a better alternative than current sources of fossil fuels	3.72 (sd=1.02)	3.20 (sd=1.14)	3.69	118.86	.00

Note: the scale used is as follows: 1=Strongly Disagree, 2=Disagree, 3=Don't care/neutral, 4=Agree, and 5=Strongly Agree.

To measure objective forest management respondents were asked to answer Yes/No to the question 'Do you currently have a forest management plan?' This was then tested to determine if there was significance between having a management plan and their agreement to key bioenergy statements. Results from this T-test indicate significant differences in 5 bioenergy statements (95% significance level, Table 16). Forest landowners with a management plan indicate stronger agreement towards the positively framed statements,

whereas, forest landowners without a management plan tended to lean more towards 'Don't care/neutral' for the positively framed statements. Conversely, forest landowners with a management plan had stronger disagreement (mean=2.17, sd=.98) towards the negatively framed question; I don't see a community benefit due to the local biomass plant than forest landowners with a management plan than those without forest management plans (mean=2.61, sd=1.12) (t(263.04)=-3.38, p=.00).

Table 16. T-test Results on the Objective Management Level of Combined Survey Respondents and Key Bioenergy Statements

	Forest Management Plan (mean ratings)				
Key Bioenergy Agreement Statement	**Yes (n=202)**	**No (n=162)**	**t**	**df**	**P Value**
In my opinion, the positive benefits associated with biomass production for our community will outweigh the negative impacts it has created in our community over the long-term	3.92 (sd=.91)	3.53 (sd=1.08)	3.16	222.66	.00
In my opinion, landowners should consider supplying biomass feedstock	3.92 (sd=.93)	3.57 (sd=1.01)	3.38	331.35	.00
Biomass production, overall, has a positive impact on our community	3.89 (sd=.93)	3.40 (sd=.98)	4.20	232.40	.00
I believe most landowners in our area support biomass production	3.84 (sd=.89)	3.44 (sd=1.01)	3.33	210.79	.00
I don't see a community benefit due to the local biomass plant	2.17 (sd=.98)	2.61 (sd=1.12)	-3.38	236.04	.00

Note: the scale used is as follows: 1=Strongly Disagree, 2=Disagree, 3=Don't care/neutral, 4=Agree, and 5=Strongly Agree.

An independent samples T-test was conducted to test the relationship between level of active management and the top reasons for forest landownership: investment, income from

timber sales, recreation, wildlife management and family legacy. This test reported a significant difference (95% significance level) in active managers (mean=4.05) and passive managers (mean=3.50) who own their forestland mainly for investment purposes (p value=.00). Although this test failed to report statistically significant differences for the remaining ownership variables, it appears there are differences in the means of active managers (mean=2.96, sd=1.36) and passive managers (mean=2.77, sd=1.51) who own their forestland mainly for recreational purposes (t(172.01)=1.16, p=.25). In addition, there are also differences in the means of active managers (mean=4.16, sd=1.14) and passive managers (mean=3.93, sd=1.35) that reported family legacy as an important ownership reason (t(213.55)=1.77, p=.07).

5.6 Income-based Forest Management

Forest landowners were relatively evenly split on the notion that forest management decisions are heavily dependent on if their income would increase (Table 17). Collectively, half of respondents agreed (33.6%) or strongly agreed (16.2%) that their forest management decisions heavily depend on if their income will increase, 32.6% of respondents were neutral, 13.9% disagreed and 3.6% strongly disagreed to forest management decisions heavily depend on if their income will increase. In addition, respondents were asked to rate their agreement on willingness to sell trees for bioenergy feedstock if their income increased (Table 17). Collectively, 55.8% agreed (37.8%) or strongly agreed (18.0%) in their willingness to sell trees for bioenergy feedstock if their income increased. Additionally, 31.6% were neutral, 9.5% disagreed and 3.2% strongly disagreed to sell bioenergy feedstock if their income increased.

Table 17. Combined Percentages of Enviva and KiOR Respondents on Income-based Management Agreement Statements

Forestland owner Response	**My forest management decisions heavily depend on an income increase (n=663)**	**I am willing to sell trees for bioenergy feedstock if I can increase my income (n=663)**
Strongly Disagree	3.6%	3.2%
Disagree	13.9%	9.5%
Neutral	32.6%	31.6%
Agree	33.6%	37.8%
Strongly Agree	16.2%	18.0%

Respondents were asked to indicate the percentage of income that comes from their forestland. Answer choices were in a Likert scale of percentages and condensed to 'any' or 'no' income from forestland. Results from the T-test conducted to test the relationship between levels of income from forestland and relative agreement to key bioenergy statements were statistically different at the 95% significance level and are presented in Table 18. Forest landowners who receive income from their land indicate a more positive response to the 4 variables 'I believe most landowners in our area support biomass production'; 'Biomass production overall has a positive impact on our community'; 'In my opinion, the positive benefits associated with biomass production for our community will outweigh the negative impacts it has created in our community over the long-term'; and 'In my opinion, using trees as a bioenergy feedstock is a better alternative than current sources of fossil fuels'.

Table 18. T-test Results on Forestland Income of Combined Survey Respondents and Key Bioenergy Agreement Statements

Key Bioenergy Agreement Statement	Income From Forestland	Mean	t	df	P Value
I believe most landowners in our area support biomass production	Any	3.96 (sd=.82)			
	None	3.36 (sd=1.06)	-4.76	211.2	.00
Biomass production, overall, has a positive impact on our community	Any	3.83 (sd=.92)			
	None	3.50 (sd=1.02)	-2.58	223.47	.01
In my opinion, the positive benefits associated with biomass production for our community will outweigh the negative impacts it has created in our community over the long-term	Any	3.89 (sd=.95)			
	None	3.54 (sd=1.04)	-2.78	238.61	.01
In my opinion, using trees as a bioenergy feedstock is a better alternative than current sources of fossil fuels	Any	3.81 (sd=1.05)			
	None	3.43 (sd=1.09)	-3.09	290.03	.00

Note: The average n=329 for any income, and average n=228 for no income. The scale used for the bioenergy agreement statements is as follows: 1=Strongly Disagree, 2=Disagree, 3=Don't care/neutral, 4=Agree, and 5=Strongly Agree.

5.7 Opinions on Environmental Impacts

Respondents were asked to indicate the type of change (if any) they have seen since the bioenergy facility was constructed. The majority of respondents did not see any change in environmental quality issues (88.1%) (Table 19). This percentage reflects the idea that most forest landowners do not see a change in local environmental issues due to the bioenergy facility. Only 9.6% of respondents noticed an increase in environmental quality issues, and less than 3% reported a decrease in environmental quality issues (2.3%).

Table 19. Combined Percentages of Enviva and KiOR Respondents on Environmental Impacts from Proximal Bioenergy Facilities

Which statement best represents your opinion about the impact of the bioenergy facility on your local environment?	**Percentage of Respondents (n=470)**
There has been no change in environmental quality issues	88.1%
There has been an increase in environmental quality issues	9.6%
There has been a decrease in environmental quality issues	2.3%

Forest landowners who indicated a change in environmental quality issues (increase or decrease) were asked to select the physical areas of the local environment that have been impacted (Figure 3). Of the respondents who perceived an environmental change (n=30), most perceived a loss of forestland (4.5%). Approximately 3.5% of respondents perceived a change in air quality, while equal percentages of respondents perceived a change in water quality (2.4%) or traffic volume (2.4%). Less than 2% of respondents perceived a change in soil quality and 3% saw a change that was not available in the response choices.

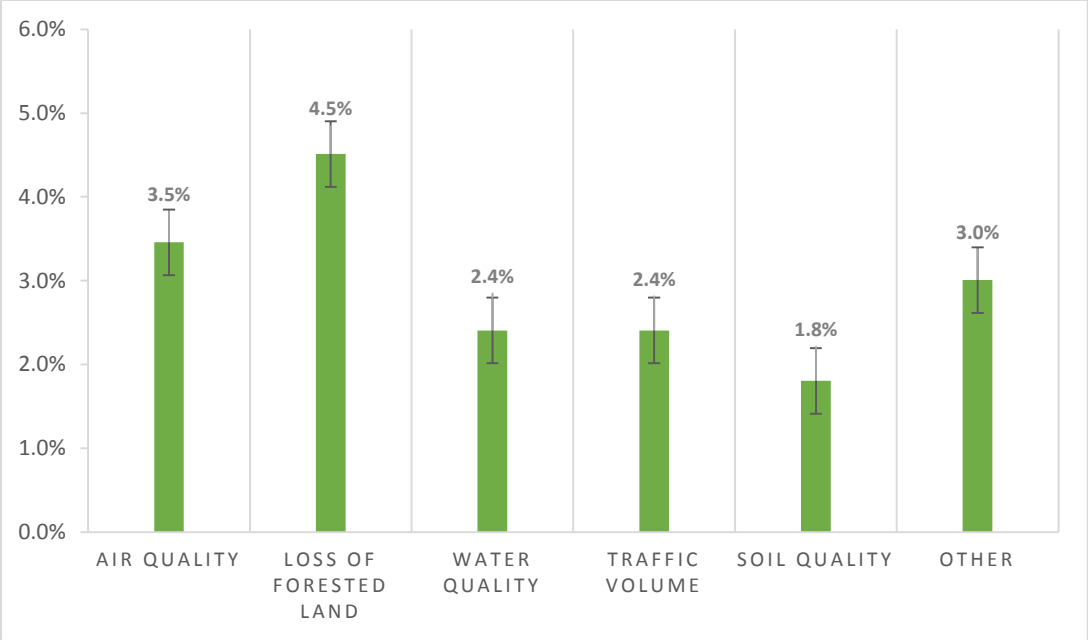

Figure 3. The main areas of environmental change as reported by NIPF landowners surrounding the Enviva and KiOR bioenergy manufacturing facilities. Percentages out of (n=30) respondents with standard error bars.

5.8 Bioenergy Harvesting Intentions

Respondents were asked a set of questions to measure the level of financial transactions between forest landowners and bioenergy facilities (Table 20). Interestingly, nearly 40% of respondents indicated they had not received income from the bioenergy facility but were interested in additional income from future timber sales to the bioenergy facilities. Approximately 24.7% of respondents indicated they are not interested in harvesting timber on their land. Conversely, 21.6% reported they had a timber harvest and were unaware of harvesting for bioenergy, and would consider harvesting for bioenergy in the future. Only 7.4% of respondents have received income due to selling trees to the bioenergy facilities near their forested property. Approximately 6.9% of respondents had a timber harvest but were not/are not interested in harvesting for bioenergy. Nearly 32% of respondents are not interested in harvesting for bioenergy or harvesting timber in general.

Nearly twice as many forest landowners indicated an interest in harvesting for bioenergy in the future (61%).

Table 20. Bioenergy Harvesting Intentions of Combined Enviva and KiOR Respondents

Since the opening of the bioenergy facility, have you received income due to selling trees from your property to the bioenergy facility?	**Percentage of Respondents (n=592)**
No, but I am interested in making money from future timber sales to the bioenergy facility	39.4%
No, I am not interested in harvesting timber on my land	24.7%
I had a timber harvest, I was unaware I could harvest timber for bioenergy, and I would consider harvesting for bioenergy in the future	21.6%
Yes	7.4%
I had a timber harvest, but I was/am not interested in harvesting for bioenergy	6.9%

A T-test was conducted to test for significant differences (95% significance) between prior bioenergy harvesting on key bioenergy agreement statements. The response choices shown in Table 20 were condensed to include "yes" or "no" answers (questions starting with "I had a timber harvest" were omitted, since there was no indication of a harvest for bioenergy). Significant differences were found for those who have previously harvested bioenergy in 4 key bioenergy agreements (Table 21). Forest landowners who have previously harvested bioenergy (mean=4.23, sd=.69) had stronger agreement than those who have not harvested bioenergy (mean=3.61, sd=1.09) in the opinion that the positive benefits associated with biomass production will outweigh the negative community impacts over time ($t(70.69)=4.37$, $p=.00$). Forest landowners who previously harvested (mean=4.21, sd=.59)

had stronger agreement than those who have not previously harvested (mean=3.65, sd=.95) in the belief that most forest landowners in the area support biomass production (t(68.91)=4.52, p=.00). Forest landowners who have previously harvested bioenergy (mean=4.16, sd=.60) had stronger agreement than those who have not harvested bioenergy (mean=3.66, sd=.98) that biomass production has an overall positive impact on the community (t(80.31)=4.06, p=.00). Similarly, those who have previously harvested bioenergy (mean=4.12, sd=.88) also had stronger agreement than those who have not previously harvested (mean=3.31, sd=1.08) that the bioenergy facility has had a positive economic impact on the community (t(57.06)=4.62, p=.00).

Significant differences were found for those who have previously harvested bioenergy in 2 key bioenergy disagreements (Table 21). Forest landowners who have previously harvested bioenergy had stronger disagreement (mean=1.81, sd=.86) than those who have not previously harvested bioenergy (mean=2.34, sd=1.18) in the opinion that biomass production is not a worthwhile community investment (t(48.59)=-3.08, p=.00). Similarly, forest landowners who have previously harvested bioenergy (mean=1.76, sd=.74) had stronger disagreement than those who have not previously harvested bioenergy (mean=2.51, sd=1.10) that there is no community benefit due to the local biomass plant (t(63.52)=-4.94, p=.00).

Table 21. T-test Results on Previous Bioenergy Harvesting of Combined Survey Respondents and Bioenergy Agreement Statements

	Previous Bioenergy Harvest (mean ratings)				
Key Bioenergy Agreement Statement	**Yes (n=44)**	**No (n=378)**	**t**	**df**	**P Value**
In my opinion, the positive benefits associated with biomass production for our community will outweigh the negative impacts it has created in our community over the long-term	4.23 (sd=.69)	3.61 (sd=1.09)	4.37	70.69	.00
I believe most landowners in our area support biomass production	4.21 (sd=.59)	3.65 (sd=.95)	4.52	68.91	.00
Biomass production, overall, has a positive impact on our community	4.16 (sd=.60)	3.66 (sd=.98)	4.06	80.31	.00
The bioenergy facility has had a positive economic impact on our community	4.12 (sd=.88)	3.31 (sd=1.08)	4.62	57.06	.00
In my opinion, biomass production is not a worthwhile investment for the local economy	1.81 (sd=.86)	2.34 (sd=1.18)	-3.08	48.59	.00
I don't see a community benefit due to the local biomass plant	1.76 (sd=.74)	2.51 (sd=1.10)	-4.94	63.52	.00

Note: the scale used is as follows: 1=Strongly Disagree, 2=Disagree, 3=Don’t care/neutral, 4=Agree, and 5=Strongly Agree.

To evaluate the relationship between management plan presence and future bioenergy harvesting intentions, simple means were calculated for both groups. Results from this T-test failed to show a significant difference in respondents who have a management plan (mean=3.76, sd=.96) and those who do not have a management plan (mean=3.43, sd=1.02) in willingness to sell trees for bioenergy feedstock if income increased (t(580.25)=4.00, p=.14) (Table 22). Results from this T-test indicates a significant difference in respondents who have a management plan (mean=1.81, sd=.39) and those who do not have a management plan

(mean=1.96, sd=.20) in any previous bioenergy harvest (t(276.81)=-4.68, p=.00).

Table 22. T-test Results on Management Plan Presence of Combined Survey Respondents and Bioenergy Harvesting Intentions

	Management Plan Presence (mean ratings)				
Bioenergy Harvesting Intentions	**Yes (n=294)**	**No (n=291)**	**t**	**df**	**P Value**
I am willing to sell trees for feedstock to produce bioenergy if I can increase my income	3.76 (sd=.96)	3.43 (sd=1.02)	4.00	580.25	.14
Since the opening of the bioenergy facility, have you received income due to selling trees from your property to the bioenergy facility?	1.81 (sd=.39)	1.96 (sd=.20)	-4.68	276.81	**.00**

Note: the scale used is as follows: 1=Strongly Disagree, 2=Disagree, 3=Don't care/neutral, 4=Agree, and 5=Strongly Agree; and 1=No, 2=Yes.

5.9 Sustainable Harvesting Practices

Very few forest landowners have included harvesting for bioenergy in their management plan (9.7%) or have a long-term supply agreement/contract with a bioenergy facility (0.8%) (Table 23). The overwhelming majority of respondents (92.8%) indicated best management practices are important to them in preserving their land and for them to supply biomass feedstock 71.5% stated they would need assurance of sustainable harvest practices (Table 23). In other words, most forest landowners in this study are aware of and place high importance on sustainable harvesting practices.

Table 23. Percentages of Combined Survey Respondents on Sustainable Harvesting Questions

Best Management Practices are important to me in preserving my land	**Percentage of Respondents (n=622)**
Yes	92.8%
No	1.3%
Unsure	5.9%
For me to supply biomass feedstock I would need assurance of sustainable harvest practices	**Percentage of Respondents (n=608)**
Yes	71.5%
No	7.4%
Unsure	21.1%
Is harvesting for bioenergy included in your management plan?	**Percentage of Respondents (n=618)**
Yes	9.7%
No	66.3%
Do not have management plan	23.9%
Do you have a long-term supply agreement/contract with the bioenergy facility?	**Percentage of Respondents (n=627)**
Yes	0.8%
No	96.3%
Unsure	2.9%

Respondents who answered ‘no’ to having bioenergy harvesting in their management plan were asked to indicate the main reason they do not want to add it (Table 24). The overwhelming majority indicated they do not have enough information on bioenergy harvesting (89.6%). A small number reported negative environmental impacts (5.4%) as the main reason to not add bioenergy harvesting. Extra time and/or money to spend on land management was reported by 3% of respondents, and 2% reported extra work for the forester.

Table 24. Combined Percentages of Enviva and KiOR Respondents on Barriers in Adding Bioenergy Harvesting to Forest Management Plans

Main reasons to not add bioenergy harvesting to your management plan	**Percentage of Respondents (n=460)**
I don't have enough information on bioenergy harvesting	89.6%
Negative environmental impacts	5.4%
Extra time/money to spend on land management	3.0%
Extra work for the forester	2.0%

5.10 Bioenergy Information Seeking and Receiving Behavior

Respondents were also asked a set of questions measuring the amount and direction of conversation between forest landowners in proximity to the bioenergy facilities (Table 25). Results indicate that 82.2% of respondents had not engaged in discussions about the local bioenergy facility in the last year, whereas 16.5% had engaged in these discussions. Of the 16.5% respondents that engaged in bioenergy facility conversations in the last year, 53.8% reported the overall conversation was positive. Only 7.7% indicated the overall conversation was negative, and equal percentages indicated a mix of positive and negative (19.2%) as well as overall neutral conversations (19.2%).

In reference to if they had heard others discuss the bioenergy facility, 79.2% of respondents reported they have not heard others discussing the local bioenergy facility in the last year. Conversely, 18.4% indicated hearing others discuss the bioenergy facility in the last year. Of the 18.4% respondents that overheard others discussing the bioenergy facilities, nearly half reported the discussions were positive (48.8%). Only 4.8% indicated the overall discussion was negative, 32.8% indicated a mix of positive and negative discussions as well as 13.6% reporting overall neutral conversations.

Table 25. Combined Percentages of Enviva and KiOR Respondents on Number and Direction of Conversations and Discussions around the Bioenergy Facilities

Have you engaged in discussion(s) about the local bioenergy facility within the last year?	**Percentage of Respondents (n=630)**
Yes	16.5%
No	82.2%
I don't remember	1.3%
How would you describe the overall discussion?	**Percentage of Respondents (n=104)**
Positive	53.8%
Negative	7.7%
A mix of both	19.2%
Neutral	19.2%
Recently, I have heard people discussing the local bioenergy facility	**Percentage of Respondents (n=630)**
Yes	18.4%
No	79.2%
I don't remember	2.3%
How would you describe the overall discussion?	**Percentage of Respondents (n=125)**
Positive	48.8%
Negative	4.8%
A mix of both	32.8%
Neutral	13.6%

Respondents were asked to indicate if they have sought out information on the local bioenergy facility (Table 26). The overwhelming majority of forest landowners (93.3%) have not sought out information, and only 6.7% have sought out information on the local bioenergy facility. Table 26 also presents the topics forest landowners are seeking out information on. Most forest landowners are seeking out information on forest management advice (14.4%) or price for their trees (14.4%). Less than 4% of forest landowners are seeking out general information on the bioenergy facility. Similarly, less than 3% of forest

landowners are seeking out information on acceptable feedstock types, the type of bioenergy product made or supply contracts for bioenergy.

Table 26. Combined Percentages of Enviva and KiOR Respondents on Information Seeking Survey Questions

Have you sought out information on the local bioenergy facility?	**Percentage of Respondents (n=639)**
Yes	6.7%
No	93.3%
Please indicate which type of information you have sought out in the last year.	**Percentage of Respondents (n=43)**
Forest management advice	14.4%
Price for my trees	14.4%
General facility information	3.9%
Acceptable feedstock types	2.3%
Type of bioenergy product made	2.2%
Supply contracts for bioenergy	2.0%

Table 27 presents the preferred information sources of forest landowners in this study. Most forest landowners are receiving information from natural resources professionals (11.4%). Approximately 7.5% received information from state agencies, 5.8% received information from family or friends and 5.3% received information from extension services. Less than 3% of forest landowners received information from: the internet, mass media, the bioenergy facility, federal agencies, university sources, social media or non-profit organizations.

Table 27. Preferred Sources of Forestry Information for Enviva and KiOR Respondents

Please describe who provided these information sources	**Percentage of Respondents (n=43)**
Natural Resources Professional (e.g. consulting forester)	11.4%
State Agencies	7.5%
Family/friends	5.8%
Extension Service	5.3%
Internet	2.8%
Mass media (e.g. Newspaper/Magazine/Radio/Television)	2.7%
Bioenergy facility	2.3%
Federal Agencies	1.1%
University Research/Sources	1.1%
Social Media	0.8%
Non-profit organizations	0.3%

Based on a T-test (95% significance), NIPF landowners who seek out information about the bioenergy facility have stronger belief that the positive benefits from biomass production in the community will outweigh the negative impacts compared to those who do not seek out information (Table 28). Although not statistically significant, the data indicates potentially that those seeking information are more likely to disagree (mean=2.19, sd=1.15) that there is no economic benefit to the community from the bioenergy facility than those who did not seek information (mean=2.40, sd=1.21)(t(180.84)=-1.49, p=.13). Results from this T-test indicated two significant differences that are presented in Table 28. Results from the T-test indicates those seeking information about the bioenergy facility are more likely to agree (mean=3.92, sd=.93) that the positive benefits of local bioenergy production will outweigh the long-term negative impacts than those who did not seek information (mean=3.66, sd=1.06)(t(209.49)=2.13, p= .03). Respondents who have sought out

information are also more likely to agree (mean=3.86, sd=.92) that bioenergy produced from trees is more environmentally friendly than those who did not seek out information (mean=3.59, sd=1.10)(t(247.95)=2.39, p=.02)

Table 28. T-test Results on the Information Seeking Behavior of Combined Survey Respondents and Bioenergy Agreement Statements

	Information Sought on Bioenergy Facility (mean ratings)				
Bioenergy Agreement Statement	**Yes (n=111)**	**No (n=280)**	**t**	**df**	**P Value**
In my opinion, biomass production is not a worthwhile investment for the local economy	2.19 (sd=1.15)	2.40 (sd=1.21)	-1.49	180.84	.13
In my opinion, the positive benefits associated with biomass production for our community will outweigh the negative impacts it has created in our community over the long-term	3.92 (sd=.93)	3.66 (sd=1.06)	2.13	209.49	**.03**
Compared to fossil fuels, bioenergy produced from trees is more environmentally friendly	3.86 (sd=.92)	3.59 (sd=1.10)	2.39	247.95	**.02**

Note: the scale used reasons is as follows: 1=Strongly Disagree, 2=Disagree, 3=Don't care/neutral, 4=Agree, and 5=Strongly Agree.

5.11 Respondent Opinions and Perceived Social Norms

Two separate simple linear regressions were conducted to predict respondent opinions on bioenergy topics on perceived social norms. Results of these regressions failed to show any relationship between these variables (Table 29). Overall, these results suggest any relationship between perceived social norms and forest landowner opinions is very weak. Only 4.4% of respondent opinions that biomass production can be explained by the belief

that community members who do not own forestland do not support biomass production (.00 significance, 95% confidence). Similarly, only 1.1% of respondent opinions that forest landowners should consider supplying biomass feedstock can be explained by the belief that community members who do not own forestland do not support biomass production (0.10 significance, 95% confidence).

Table 29. Linear Regression Results of Combined Respondent Opinions on Bioenergy Topics and Perceived Social Norms

	Variable	**R^2**	**Sig.**
Dep. Variable 1	In my opinion, biomass production is not a worthwhile investment for the local economy		
Ind. Variable 1	I believe most local community members who don't own forestland do not support biomass production	0.04	0.00
Dep. Variable 2	In my opinion, landowners should consider supplying biomass feedstock		
Ind. Variable 2	I believe most local community members who don't own forestland do not support biomass production	0.01	0.10

5.12 Social Life Cycle Analysis Outcomes

The overall SLCA outcomes from this study are generally neutral and positive, with a couple negative outcomes (Table 30). The negative or positive rating, and color coding of the indicator and outcome determines the color and rating of each category. Each outcome is based on the response for each unit (survey question). The outcomes are equally weighted, based on the assumption that each question has equal importance in reporting the overall SLCA results.

Table 30. The Overall Social Life Cycle Analysis Outcomes for Enviva and KiOR Respondents

Category	Indicator	Outcome
Social well being	Opinion on Environmental well being	No Change **(88%)**
	Income from land	Agree/Strongly Agree **(56%)**
	Increase in acreage	No **(99%)**
Energy security	Belief in bioenergy contribution	Mean Response **(3.2)**
External trade	Belief in bioenergy impact	Mean Response **(3.6)**
Profitability	Long term supply (contract)	No **(96%)**
Resource conservation	Desire to harvest forest land sustainably	BMP's Are Important **(93%)**
	Utilizing logging slash	No Impacts **(36%)**
	Change in forest productivity	No Change **(31%)**
Social acceptability	Public opinion	Mean Response **(3.7)**
	Community benefit	Mean Response **(3.7)**
	Positive opinion about biomass production	Mean Response **(3.7)**
	Supply willingness	Interest in Future Harvest **(40%)**
	Sharing support with community	Mean Response **(2.9)**
Emotional investment	Reason for owning land	Family Legacy **(4.1)**
	Level of management	Management Plan **(50%)**
	Land transaction	Inherited **(49%)**
Recreational impacts	Documented wildlife disturbances	No change **(52%)**
	(Recreational) holding capacity	Interested in Increase **(42.4%)**
Peer influence/outside information	Information seeking behavior	No **(93%)**

The social well-being category had 2 positive outcomes and 1 negative outcome (Table 30). The positive outcomes are shown in forest landowner opinions of the environmental impact of the bioenergy facility (88% saw no change) and 56% agreed or strongly agreed that they are willing to sell trees for bioenergy feedstock if there was an increase in their income. Conversely, the overwhelming majority of forest landowners (99%)

agreed they have not purchased more forestland due to the establishment of the bioenergy facility.

Forest landowners had relatively neutral opinions of the impact of bioenergy and the criticality towards national security (mean response 3.2 out of 5, table 30). However, the external trade category had a relatively positive outcome. Forest landowners tend to agree more that trees as a bioenergy feedstock are a better alternative than current fossil fuels (mean response 3.6 out of 5). Not surprisingly, the profitability category had a negative outcome. The overwhelming majority of forest landowners (96%) do not currently have a long-term supply contract with the local bioenergy facility.

Resource conservation had 1 positive and 2 neutral outcomes, with an overall neutral category outcome (Table 30). The overwhelming majority of forest landowners (93%) have a desire to harvest forestland sustainably, with a strong belief that BMP's are important to them in preserving their land. However, only 36% of forest landowners in this study agreed that harvesting logging slash for bioenergy production does not compromise forest health. Similarly, only 31% of forest landowners agreed that harvesting logging slash for bioenergy is not detrimental to the site's productivity.

The social acceptability category had 2 neutral and 3 positive outcomes, with an overall positive category outcome (Table 30). The public opinion, community benefit and positive opinion about biomass production indicators all had a positive outcome (mean response 3.7 out of 5). These positive outcomes show that forest landowners in this study believe forest landowners support biomass production, biomass production has an overall positive community impact and these positive impacts will outweigh the negative impacts over the long-term. Conversely, forest landowners in this study had relatively neutral

outcomes in the supply willingness and sharing support with community indicators. Nearly 40% of forest landowners are interested in a future harvest, in addition to a rating of 2.9 (out of 5) that community members who do not own forestland do not support biomass production.

The emotional investment category had 1 positive and 2 neutral outcomes, with an overall neutral category outcome (Table 30). Forest landowners in this study mainly own their forestland for family legacy purposes (mean response 4.1 out of 5). This study assumed forest landowners would have more emotional than economic ties to their land. This outcome showed mainly an emotional tie to their land, giving this indicator a positive outcome. However, the level of management and land transaction indicators had relatively neutral outcomes. Nearly 50% of forest landowners in this study have a forest management plan, and approximately 49% inherited their land. Although these are significant numbers, the response rate did not reach the 66% threshold to be considered a positive outcome.

The recreational impacts category had an overall neutral outcome (Table 30). Approximately 52% of forest landowners did not report a change on wildlife populations on their land since the bioenergy facility was constructed. Similarly, 42.4% are not interested in maintaining recreational use on their property. The peer influence/outside information category had an overall negative outcome. The overwhelming majority of forest landowners (93%) have not sought out information on the local bioenergy facility

6. Discussion

Study results showed that the majority of respondents were male, over 60 years of age, well-educated and had an average income between $50,000 and $100,000/year. Results are consistent with results on southern forest landowner demographics, which showed the average landowner was well educated and averaged 60 years of age (Butler, 2004). Most forestland in this study is under sole or family ownership, and has a mixture of hardwoods and pine or planted pine species. Nearly all landowners in this study inherited or purchased their forestland from their parents, their spouse's parents or another individual. Demographic results from this study are consistent with national results (Butler 2008).

Nearly half of landowners agreed or strongly agreed that their forest management decisions heavily depend on the potential for increase in income, and just over half are willing to sell trees to produce bioenergy if their income will increase. It is evident that land acquisition type (purchased vs. inherited) impacts the opinion that positive benefits from biomass production will outweigh the negative impacts in the community. Speculation can be made as to why, but it is clear that those who have financially invested in their land have a different view of the overall impacts of the bioenergy facility.

Results from this study show family legacy, investment, wildlife management and income from timber sales as the main reasons for forest landownership. Although response choices were different in this study, most of the main ownership reasons are similar to national results. Respondents in this study have a substantially higher percentage of forest management plans (50% respectively) when compared to the national average (roughly 3-

4%) (Butler 2004, Butler 2008). Over half of the respondents in this study are participating in an assistance program, whereas, only 16% are participating in forest certification. Based on the outcomes and similar demographic results in this study, one would expect similar results for the southeast U.S. and potentially on a national scale.

Results of the study indicate that the success level of a bioenergy facility does not impact forest landowner perceptions, beliefs and related management behaviors. Study results also indicate that normative social influence will have no impacts on forest landowner perceptions, opinions or related management behaviors. Although no significant differences were found between study site and agreement statements, KiOR respondents agreed more strongly than Enviva respondents to the belief that most forest landowners in the area support biomass production. This finding is in opposition to the hypothesis. If the hypothesis was accepted, Enviva respondents would agree more strongly than KiOR respondents that forest landowners in the area support biomass production. This assumption is based on the presence of the success level of Enviva and the negative press surrounding KiOR.

The overwhelming majority of respondents (90%) stated there was no change in environmental quality issues, and only 4.5% of the respondents who reported a change were concerned about the loss of forestland and air quality (3.5%). In a recent study, respondents cited noticeable odor and traffic congestion as environmental issues surrounding the bioenergy facility (Selfa *et al* 2011). The perceived environmental impacts from previous studies do not overlap with the perceived impacts in this study. The reasoning for the difference in the results are unclear, but assumptions can be made about the difference in geographic area, and sample population or proximity to bioenergy facilities (different radius). It is promising that only a small percentage of respondents in this study perceive changes in

environmental quality issues, since a main reason for opposing facility construction is perceived negative environmental impacts and impacts on quality of life for rural communities (Selfa *et* al 2011). In order for forest landowners to support construction of and potentially provide feedstock to bioenergy facilities, they need to be assured that there is little change in environmental quality issues and their quality of life is not reduced from the facility operations. This finding can push bioenergy facilities to strive for environmentally responsible practices during construction and operation.

Similarly, respondents in this study have relatively neutral opinions that trees as a bioenergy feedstock is critical to national security. However, the opinions were stronger when asked if trees as a bioenergy feedstock is a better alternative than current sources of fossil fuels. These findings suggest future research focusing on understanding why NIPF forest landowners are more concerned with alternative fuel sources than national security, when considering bioenergy harvesting. This finding also shows the need for comparison between perceived changes in environmental quality issues between non-renewable and renewable energy facilities, to further ensure the continued success of the bioenergy industry.

Nearly half of NIPF landowners in this study make forest management decisions based on the potential for increase in income, and approximately half are willing to sell trees to produce bioenergy if their income will increase. Although NIPF landowners in this study make management decisions based on income, other authors reported forest landowner hesitation in changing forest management objectives to harvesting woody bioenergy, even if the forest landowners can make a profit (Blennow *et al* 2014). The authors conclude that attitudes toward supplying woody biomass feedstock are not solely based on changes in prices and markets (Blennow *et al* 2014). It is evident that there are factors impacting NIPF

landowner willingness to supply woody biomass for feedstock, and future studies should attempt to uncover these missing factors.

The overwhelming majority of respondents (99%) have not purchased additional forested acres since the establishment of the bioenergy facility. Similarly, 25% of respondents in this study are not interested in harvesting timber on their property. This is also not surprising, considering half of the main reasons for ownership were not related to financial gains. The main reasons for owning forestland in this study are family legacy, investment, wildlife management and income from timber sales. The main reasons for forest landownership are consistent with national results (Butler 2004, Butler 2008). Assumptions can be made that forest landowners who report family legacy or wildlife management as the main reason are more interested in the aesthetic and enjoyment aspects of forest landownership. These respondents may not be as concerned with income from harvesting, as respondents who cited investment or timber sales as the main reasons for forest landownership. Since nearly all respondents are not interested in purchasing additional acres to harvest for bioenergy, future studies should form new indicators and units to measure social well-being.

Approximately 7% of the respondents indicate receiving timber income from selling feedstock to the bioenergy facilities and less than 4% of respondents indicate having long-term supply contracts with the facility. Neither of these outcomes indicates that forest landowners are unwilling to supply biomass to the facilities. First the facilities have only been open for a few years and the majority of forest landowners (61%) are interested in income from selling timber to the bioenergy facilities but have not conducted a recent timber harvest or have conducted a harvest but were unaware of the bioenergy market. Second, the

bioenergy facilities may not be interested in long-term contracts with forest landowners who own small acreages and or will only harvest timber once or twice while the land is under their ownership.

Although a lack of information is cited as the main reason to not include bioenergy harvesting in a management plan, 93% of forest landowners have not sought out information on Enviva or KiOR. This survey did not ask respondents to indicate if they sought out information on bioenergy harvesting. Conversely, Velde *et* al (2014) reported 86% of general public respondents seeking out information on biofuels to some extent. The reason for the large opposition is unclear, but assumptions can be made about the demographics of each group. Forest landowners tend to have a more narrow demographic than the general public, thus, information given to NIPF landowners on bioenergy harvesting and facilities needs to come from trustworthy sources through information channels that they prefer. In this study, the preferred information sources for these respondents were natural resources professionals, and state agencies. These results are consistent with national results that reported private consultants and state forestry agencies as the main sources of forest management advice (Butler 2008). Future work done on NIPF landowners and bioenergy should assess what topics and how much information forest landowners are seeking out about bioenergy, irrespective of facility location.

Since most respondents in this survey have a written management plan and report consulting foresters as the preferred information source, these professionals need to be knowledgeable on bioenergy topics forest landowners might inquire about. If these sources do not have this information, it is highly unlikely that a majority of them will receive the information they seek in helping them make the decision to harvest for bioenergy. Also, if

the sources and types of information are not the preferred methods, it is evident why the knowledge levels are low. Of the respondents who have not previously sought out information on the bioenergy facility, nearly 1/3 have considered or are considering seeking out this information. Answers to this question may be biased since respondents read a decent amount of text on bioenergy prior to answering this question. However, it is promising that at least 1/3 of forest landowners indicated an interest in seeking out information on bioenergy.

Most forest landowners have not engaged in conversation or heard discussions about the bioenergy facility within the last year. Of these respondents, nearly half reported the conversations and discussions as positive, and very few stated they were negative. These results are interesting when considering the success level of each facility. Although KiOR has closed and is receiving negative press, the forest landowners surrounding that facility do not hear or engage in any more negative conversations than those around Enviva, which is also in the press in a negative connotation. It is evident that the success level of a bioenergy facility does not determine the direction of conversations NIPF landowners will have about the facility. This can be seen as a positive or negative social indicator in the success levels of future bioenergy facilities. It is positive because it can show that press does not typically impact forest landowners, and if a facility has short-term negative press, it might not deter forest landowners from having an overall positive view of the facility. It can also be seen as negative because although one facility may be successful and benefit a large number of forest landowners, only a small number are discussing the facility.

A fair amount of the negative press surrounding KiOR is at the state level, and is more likely to be on the local news channels. Enviva is a global company, with facilities and ports across the southeastern United States. Negative press surrounding Enviva may be far

less likely to broadcast on local news. Rather, Enviva's negative press can be found on non-profit or environmental group websites such as the Natural Resources Defense Council or The Dogwood Alliance or in newspapers such as the Washington Post. The major difference in KiOR and Enviva news sources is the amount of searching required to locate news on these facilities. Since less than 3% of respondents in this study utilize newspaper/television as a main source of information on bioenergy, this helps to explain why the success level of the facility and associated publicity does not impact NIPF landowner conversations or discussions about the facility.

Respondents who sought out information on the bioenergy facility had higher agreement that the positive benefits of the bioenergy facility will outweigh the negative impacts over the long run, and that bioenergy produced from trees is more environmentally friendly. The fact that forest landowners who sought out information on the bioenergy facility had more favorable opinions is an interesting finding. Since at least half of respondents in this study have a four-year degree, it is safe to assume they are well educated. Since these forest landowners are seeking out information, it is also safe to assume they want to be educated on topics that can influence their management strategies or income. That being said, since forest landowners in this study are well educated and seem to be unaffected by negative press, these forest landowners seem to be forming their own favorable opinions about local bioenergy production. However, the argument can also be made that since these forest landowners only agreed more strongly on a few bioenergy statements, there is not enough evidence to state that their opinions are in fact stronger than those who did not seek out bioenergy information. Assumptions can be made that the information these forest

landowners sought out or received alluded to strongly positive information, thus, impacting their responses to these questions.

Most forest landowners in this study agreed that the positive benefits associated with biomass production in the community would outweigh the negative impacts in the long term. Similarly, more than 1/3 of respondents in a recent study stated the benefits of a local ethanol plant moderately or greatly outweighed the costs (Selfa *et al* 2011). Approximately half of respondents (52%) did not perceive any change in wildlife populations on their forestland and only a few respondents (5%) reported a decrease in wildlife populations in the procurement radius. Nearly 1/3 of respondents do not believe harvesting logging slash for bioenergy negatively impacts wildlife habitat. Similarly, just over 1/3 of respondents do not believe harvesting logging slash for bioenergy feedstock compromises forest health. These beliefs can also contribute to forest landowner acceptance and support of the bioenergy facility. Since the majority of forest landowners do not report a decrease in wildlife populations, and wildlife is one of the top reasons for owning forestland, it is safe to assume that this furthers an overall positive view of the bioenergy facilities in this study. The less negative impacts forest landowners report, the less likely they are to have a negative view of the local bioenergy facilities.

7. Avenues for Future Research

This study looked at NIPF landowners who owned 20 or more acres of forestland within a 60-mile transportation distance of two bioenergy facilities in the southeastern United States. This limited sample of forest landowners excludes a substantial amount of people who

could have contributed to a more diverse data set. Future studies should utilize and expand on these survey methods to compare the NIPF landowner results with the general public, policy makers, non-profit groups, entry-level employees and corporate level employees of the bioenergy facility. In comparing these groups, we can have a more holistic understanding of the social impacts of bioenergy facilities.

Social Life Cycle Analysis is a relatively new tool, with very little groundwork and research to compare results to. Since there is no set framework, it is difficult to form categories, indicators and units. The lack of framework also makes it difficult to understand if the indicators will measure the social impacts they intend to measure. By conducting SLCA on more products, such as within the alternative energy field, and diverse populations the SLCA will improve as tool for all who use it.

As previously stated, results of this study suggest future research to understand why NIPF landowners are more concerned with alternative fuel sources than national security, when considering bioenergy harvesting. These results also show the need to compare perceived changes in environmental quality issues between non-renewable and renewable energy facilities, to further ensure the continued success of the bioenergy industry. Future work done on NIPF landowners and bioenergy should assess what topics and how much information forest landowners are seeking out about bioenergy, irrespective of facility location. It is evident that there are factors impacting NIPF landowner willingness to supply woody biomass for feedstock, and future studies should attempt to uncover these missing factors.

Similarly, since nearly all respondents are not interested in purchasing additional acres to harvest for bioenergy, future studies should form new indicators and units to measure social well-being for SLCA.

8. Conclusions

The success level of a bioenergy facility does not appear to have an impact on NIPF landowner opinions, attitudes and management surrounding bioenergy. Since the success level does not have an impact, other factors should be analyzed to determine the true social impacts on forest landowners. When analyzing other factors, there are many ways to characterize forest landowners to group them by demographics, beliefs, attitudes or behaviors. These groups should be utilized to further study NIPF landowners, in addition to being able to better conduct education and outreach.

Although normative social influence does not appear to impact NIPF landowners, NIPF landowners tend to have positive opinions about the bioenergy facility and the level of bioenergy support from other forest landowners in the community. This level of support is amplified with NIPF landowners who have a management plan, those who draw income from their forestland and those who purchased their forestland. Further studies need to be conducted to further analyze NIPF landowner trends in regards to bioenergy topics.

The breadth of knowledge on SLCA is very limited and narrow in focus (Mbohwa *et al* 2006, Dale *et al* 2013a, Dale *et al* 2013b). This study only draws conclusions from one stakeholder group in two geographic regions, and two very similar bioenergy products. As previously

stated, there are a vast number of stakeholder groups and alternative energy sources that would benefit from an SLCA study. Future SLCA work should span a wider range of stakeholder groups and various alternative energy sources. An increase in SLCA studies will help to continue building the framework (categories, indicators and units) for different stakeholder groups. Establishing a framework will make SLCA easier to conduct, thus, a more widely used qualitative research tool.

9. References Cited

Blennow, Kristina, Erik Persson, Marcus Lindner, Sonia Pacheco Faias and Marc Hanewinkel. Forest owner Motivations and Attitudes Towards Supplying Biomass for Energy in Europe (2014). *Biomass and Bioenergy* 67, 223-230.

Butler, Brett J. Family Forest Owners of the United States, 2006. (2008). *Northern Research Station, USDA Forest Service*. U.S. Department of Agriculture, Forest Service.

Butler, Brett J., and Earl C. Leatherberry. America's Family Forest Owners (2004). *Journal of Forestry*. 107 (7) 4-8.

Clendenning, Greg, Donald R. Field and Dana Jensen (2013) A Survey of Seasonal and Permanent Landowners in Wisconsin's Northwoods: Following Dillman and Then Some, *Society & Natural Resources: An International Journal*. 26 (2) 226-237.

Dale, Virginia H., Rebecca A. Efroymson, Keith L. Kline, Matthew H. Langholtz, Paul N. Leiby, Gbadebo A. Oladosu, Maggie R. Davis, Mark E. Downing, and Michael R. Hilliard. Indicators for Assessing Socioeconomic Sustainability of Bioenergy Systems: A Short List of Practical Measures. *Ecological Indicators* 26 (2013) 87-102.

Dale, Virginia H., Matthew H. Langholtz, Beau M. Wesh, and Laurence M. Eaton. Environmental and Socioeconomic Indicators for Bioenergy Sustainability as Applied to Eucalyptus. *International Journal of Forestry Research* 10 (2013) 1-10.

Davis, Sarah C., Kristina J. Anderson-Teixeira, and Evan H. Delucia. Life-cycle Analysis and the Ecology of Biofuels (2009). *Trends in Plant Science* 14 (3) 140-46.

Delshad, Ashlie B., Leigh Raymond, Vanessa Sawicki and Duane T. Wegener. Public Attitudes toward Political and Technological Options for Biofuels (2010). *Energy Policy* 38, 3414-3425.

Delshad, Ashlie and Leigh Raymond. Media Framing and Public Attitudes toward Biofuels (2013). *Review of Policy Research* 30 (2) 190-210.

Dillman, D.A., Smyth, J.D. & Christian, L.M. (2009). Internet, mail and mixed mode surveys: The tailored design method (3rd ed.), New York, NJ: John Wiley & Sons, Inc.

Dreyer, Louise C., Michael Z. Hauschild, and Jens Schierbeck. A Framework for Social Life Cycle Impact Assessment (2006). *The International Journal of Life Cycle Assessment* 11 (2) 88-97.

Efroymson, Rebecca A., Virginia H. Dale, Keith L. Kline, Allen C. Mcbride, Jeffrey M. Bielicki, Raymond L. Smith, Esther S. Parish, Peter E. Schweizer, and Denice M. Shaw.

Environmental Indicators of Biofuel Sustainability: What About Context? (2012). *Environmental Management.* 51 (2) 291-306.

Galadima, A. Z.N. Garba, B.M. Ibrahim, M.N. Almustapha, L. Leke and I.K. Adam (2011). Biofuels Production in Nigeria: The Policy and Public Opinions. *Journal of Sustainable Development* 4 (4) 22-31.

Gass, R.J., M. Rickenbach, Schulte, L.A. and K. Zeuli. Cross-boundary Coordination on Forested Landscapes: investigating Alternatives for Implementation (2009). *Environmental Management*. 43 (1) 107-117.

Gauthier, Caroline. Measuring Corporate Social and Environmental Performance: The Extended Life-Cycle Assessment. *Journal of Business Ethics* 59 (2005) 199-206.

Giles, William F., and Hubert S. Field. Effects of Amount, Format and Location of Demographic Information on Questionnaire Return Rate and Response Bias of Sensitive and Nonsensitive Items (1978). *Personnel Psychology*. 31 (3) 549-559.

Griebhammer, Rainer, Catherine Benoit, Louise Camilla Dreyer, Anna Flysjo, Andreas Manhart, Bernard Mazijn, Andree-Lise Methot and Bo Weidema. Feasiblity Study: Integration of Social Aspects into LCA (2006). UNEP-SETAC Life Cycle Initiative.

Groves, Robert M., Robert B. Cialdini and Mick P. Couper. Understanding the Decision to Participate in a Survey (1992). *Public Opinion Quarterly.* 56 (4) 475-495.

Gruchy, Steven R., Donald L. Grebner, Ian A. Munn, Omkar Joshi and Anwar Hussain. An Assessment of Nonindustrial Private Forest Landowner Willingness to Harvest Woody Biomass in support of Bioenergy Production in Mississippi: A Contingent Rating Approach (2012). *Forest Policy and Economics* 15, 140-145

Hohenstein, William G., and Lynn L. Wright. Biomass Energy Production in the United States: An Overview. (1994). *Biomass and Bioenergy.* 6 (3) 161-73.

Hujala, Teppo and Jukka Tikkanen (2008). Boosters of and Barriers to Smooth Communication in Family Forest Owners' Decision Making. *Scandinavian Journal of Forest Research* 23 (5) 466-477.

Hujala, Teppo, Jouni Pykalainen and Jukka Tikkanen (2007). Decision Making Among Finnish Non-industrial Private Forest Owners: The Role of Professional Opinion and Desire to Learn. *Scandinavian Journal of Forest Research.* 22 (5) 454-463.

Jensen, Jill R., Kathleen E. Halvorsen, and David R. Shonnard. Ethanol from Lignocellulosics, U.S. Federal Energy and Agricultural Policy, and the Diffusion of Innovation. (2011). *Biomass and Bioenergy* 35 (4) 1440-453.

Jørgensen, Andreas, Agathe Le Bocq, Liudmila Nazarkina, and Michael Hauschild. Methodologies for Social Life Cycle Assessment. (2007). *The International Journal of Life Cycle Assessment* 13 (2) 96-103.

Jørgensen, Andreas, Matthias Finkbeiner, Michael S. Jørgensen, and Michael Z. Hauschild. Defining the Baseline in Social Life Cycle Assessment. *The International Journal of Life Cycle Assessment* 15 (2010) 376-84.

Joshi, Omkar, and Sayeed R. Mehmood. Factors Affecting Nonindustrial Private Forest Landowners' Willingness to Supply Woody Biomass for Bioenergy. *Biomass and Bioenergy* 35.1 (2011) 186-92.

Joshi, Omkar, Donald L. Grebner, Anwar Hussain, and Stephen C. Grado. Landowner Knowledge and Willingness to Supply Woody Biomass for Wood-based Bioenergy: Sample Selection Approach. *Journal of Forest Economics* 19 (2013) 97-109.

Kaetzel, Brandon R., Indrajit Majumdar, Larry D. Teeter, and Brett J. Butler. Regional Differences among Family Forest Landowners Using National Woodland Owner Survey Results. *Southern Journal of Applied Forestry* 36.3 (2012) 141-45.

Krecjie, R.V., and Morgan, D.W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement.* 30, 607-610.

Knoot, Tricia G., and Mark Rickenbach. Best Management Practices and Timber Harvesting: The Role of Social Networks in Shaping Landowner Decisions (2011). *Scandinavian Journal of Forest Research* 26, 171-182.

Leitch, Zachary J., John M. Lhotka, G. Andrew Stainback and Jeffrey W. Stringer. Private Landowner Intent to Supply Woody Feedstock for Bioenergy Production (2013). *Biomass & Bioenergy* 56, 127-136.

Marsden, Peter V. Network Data and Measurement (1990). *Annual Review of Sociology.* 16, 435-463.

McBride, Allen C., Virginia H. Dale, Latha M. Baskaran, Mark E. Downing, Laurence M. Eaton, Rebecca A. Efroymson, Charles T. Garten, Keith L. Kline, Henriette I. Jager, Patrick J. Mulholland, Esther S. Parish, Peter E. Schweizer, and John M. Storey. Indicators to Support Environmental Sustainability of Bioenergy Systems. *Ecological Indicators* 11 (2011) 1277-1289.

Mbohwa, Charles, and Nonhlanhla Myaka. Social Life Cycle Assessment of Biodiesel in South Africa: An Initial Assessment. *Department of Quality and Operations Management, University of Johannesburg* (2006) 1-4.

Miettinen, Pauli, and Raimo P. Hämäläinen. How to Benefit from Decision Analysis in Environmental Life Cycle Assessment (LCA). *European Journal of Operational Research* 102 (1997) 279-94.

Miller, Cheryl, Kathryn Fernholz, Steve Bratkovich, and Jim Bowyer. (2013). Community Driven Biomass Energy Opportunities: A Northern Minnesota Case Study.

Mowen, John C., and Robert B. Cialdini. On Implementing the Door-in-the-Face Compliance Technique in a Business Context (1980). *Journal of Marketing Research.* 17 (2) 253-258.

Selfa, Theresa, Laszlo Kulcsar, Carmen Bain, Richard Goe, and Gerad Middendorf. Biofuels Bonanza?: Exploring Community Perceptions of the Promises and Perils of Biofuels Production." *Biomass and Bioenergy* 35 (2011) 1379-389.

Straka, Thomas J., Harold W. Wisdom, and James E. Moak. Size of Forest Holding and Investment Behavior of Non Industrial Private Owners. *Journal of Forestry* 82.8 (1984) 495-96.

Susaeta, A., Alavalapati, J., Lal, P., Matta, J. R., & Mercer, E. (2010). Assessing Public Preferences for Forest Biomass Based Energy in the southern United States. *Environmental Management.* 45 (4) 697–710.

Wegener, Duane T., and Janice R. Kelly. Social Psychological Dimensions of Bioenergy Development and Public Acceptance. *BioEnergy Research* 1 (2008) 107-17.

Young, Robert A., and Michael R. Reichenbach. (1987) Factors Influencing the Timber Harvest Intentions of Nonindustrial Private Forest Owners. *Forest Science* 33.2 381-93.