October 2019

The Wood Pellet Industry in the United States South: An Exploratory Study of Resident Environmental, Social, and Economic Perceptions

Mason Thomas LeBlanc
Louisiana State University and Agricultural and Mechanical College

THE WOOD PELLET INDUSTRY IN THE UNITED STATES SOUTH: AN EXPLORATORY STUDY OF RESIDENT ENVIRONMENTAL, SOCIAL, AND ECONOMIC PERCEPTIONS

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The School of Renewable Natural Resources

by
Mason Thomas LeBlanc
B.S., Louisiana State University, 2018
December 2019

ACKNOWLEDGEMENTS

I would first like to thank my major professor, Dr. Richard Vlosky, whose continuous guidance and encouragement made this thesis possible. I am extremely grateful for your constructive criticisms, scrupulous proofreading, outstanding mentorship, and our down-to-earth conversations. To my graduate committee members, Dr. Niels de Hoop and Dr. Sun Joseph Chang, School of Renewable Natural Resources, thank you for your invaluable feedback and support, not only throughout this process, but my entire college career. I must also thank Dr. Mike Kaller, School of Renewable Natural Resources, for your continuous direction during my time at LSU. Lastly, I would like to express my gratitude to my family, especially my parents, for the understanding, love, and support I have relied on throughout this journey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This thesis research provides insight into the wood pellet manufacturing industry from the perspectives of residents in the US South, focusing on environmental, social, and economic constructs. The region is the largest producer and exporter of wood pellets in the world. The focus of previous research on wood pellets has focused on environmental, energy, and economic attributes. This study is the first of its kind to expand the research to investigate in-depth socio-economic dynamics and fill a general gap in knowledge of the relationship between the wood pellet industry and public supply-side issues in the region. Two rounds of a web-based survey were sent to 7,500 residents in the two pellet-producing sub-regions within the US South: the Gulf Coast (Louisiana & Mississippi) and the Atlantic Coast (South Carolina, North Carolina, & Virginia). Within these regions, surveys were sent to randomly selected residents, by zip code, 18 years or older, who live within a 50-mile radius of selected pellet mills or in the two largest Metropolitan Statistical Areas (MSA) within each state containing a selected pellet mill. Comparisons were made between 1) urban (MSA) and rural areas (50-mile radius from a pellet manufacturer mill) and 2) Gulf Coast and Atlantic Coast regions. Compared to urban respondents, rural respondents were overall more accepting of the wood pellet industry and its environmental, social, and economic impacts. Overall, Gulf Coast respondents were more accepting to this sector than Atlantic Coast respondents. Policy makers in the formation of public policy and industry to evaluate their current and future potential effects in the Southern Region can use the implications of this study.

CHAPTER 1. INTRODUCTION

1.1. Introduction and Problem Statement

Adverse environmental effects of fossil fuels accompanied by increasing world energy demand have stimulated global consciousness toward climate change issues and renewable sources of energy. Over the past 50 years, the reduction of greenhouse gas (GHG) emissions and utilization of renewable energy sources (RES) have received significant attention in global energy and environmental policy. As a result, biomass energy, in the form of wood pellets, has taken center stage in the realm of RES over the past decade, as a highly subsidized and widely utilized alternative to fossil fuels, particularly coal, for large-scale energy-generation. Global consumption of wood pellets has been on an upward trajectory for the past decade, particularly in the two largest demand regions, the European Union (EU) and Asia; demand is expected to continue increasing under current policy conditions (Thrän, Peetz, & Schaubach, 2017).

Concurrent with increasing demand, the United States' (US) industrial wood pellet manufacturing industry has developed into the most significant global producer and exporter of pellets; predominately from the Southern[1] region (UN-FAO, 2018). Over 95% of production in the South is exported to the EU, where wood pellets have become an integral part of strategies to mitigate carbon dioxide (CO_2) and other GHG emissions (Henderson, Joshi, Parajuli, & Hubbard, 2017). The US has received considerable attention as exports have increased from negligible amounts in the early 2000s to around 6 million metric tons (MMt) in 2018 (Greene, 2019).

The literature on wood pellets has tended to focus on chemical and energy characteristics compared to fossil fuels, carbon sequestration, GHG emissions, and other pollutants. Other

[1]Southern states refer to Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas and Virginia

environmental and economic issues have also been studied. Examples of issues in the environmental area include timber harvesting, life-cycle analysis of pellet production, and energy expenditures in the supply chain from the forest to end-users. In the economic area, analyses tend to examine policy instruments, economic impacts, and investment opportunities that have evolved with increasing demand. However, while these aspects of wood pellets have been studied fairly intensively, a limited amount of research has focused on social dimensions of the industry.

Specifically, there is a significant gap in the knowledge-base regarding the relationship between the US wood pellet manufacturing industry and the general public. Overall, no primary empirical research has been conducted to date that examines the environmental, social, and economic perceptions of residents as they relate to the industry.

1.2. The Study and Definitions

Public concern is evident by wood pellet manufacturers. For example, Enviva, the largest pellet manufacturer in the world, recently created a new corporate-level position of Community Outreach Manager. This manager leads engagement and communicates the company's efforts in sustainable forest management and restoration amongst other environmental initiatives, through education programs and community outreach. As the industrial wood pellet industry grows, it is vital to understand public perceptions, as they may have implications on the formation of policy, corporate investment in manufacturing facilities, the future of wood pellet bioenergy in the US, and future environmental, social, and economic impacts of this emerging industry.

This study investigates the attitudes, awareness, behaviors, perceptions, and underlying issues of the wood pellet manufacturing industry from perceptions of the general public,

specifically those of residents living near or in communities where pellet mills are located. This study examines these issues in the context of environmental, social, and economic constructs.

This study was conducted by administering a web-based survey to residents within a 50-mile radius of selected pellet mills and residents living within the two largest metropolitan statistical areas (MSA) in each state where these mills are located. Although it would be valuable to understand the pellet industry's perceptual dynamics from the perspective of many stakeholders, due to time and funding constraints, as well as the pressing need to study resident opinions, residents were the focal group.

In this thesis, "pellet manufacturing facility" or "pellet mill" refers to a facility where industrial pellets are produced and "power station" refers to an industrial facility that produces energy in the form of heat, electricity, or both. The US Census Bureau defines urban areas as areas with a population of 50,000 or more people, and rural areas are defined as areas not included within an urban area. However, since zip code boundaries, rather than cities, were used to identify residents within 50-mile radii of pellet mills, residents within the 50-mile radii were the rural sample and residents within MSAs were the urban sample. The Census Bureau defines MSAs as core areas containing a substantial population nucleus, together with adjacent communities having a high degree of economic and social integration.

1.3. Study Objectives

Specific research objectives of the study are to:

1. Identify the perceptions of a subset of the general public on the US wood pellet manufacturing industry across environmental, social, and economic dimensions.

2. Compare residential perceptions based on contrasts in population and geographic location (a. Rural mill communities; b. Urban comparison) (a. Gulf Coast; b. Atlantic Coast)

CHAPTER 2. PRIMARY DRIVERS OF INDUSTRIAL WOOD PELLET SECTOR DEVELOPMENT

2.1. Climate Change

2.1.1. An Increasing Awareness: 1850-1978

Carbon dioxide and other GHGs have long been naturally emitted and sequestered throughout Earth's history. However, natural processes regulating Earth's atmospheric balance have not adequately adjusted to increasing anthropogenic activity. Human activity is considered the most significant source of atmospheric GHGs over the past 150 years (IPCC, 2007).

In 1856, American scientist Eunice Newton Foote discovered the atmospheric warming effect of CO_2, which she published in "Circumstances Affecting the Heat of the Sun's Rays." In 1896, Swedish chemist Svante Arrhenius further added to Foote's results by affirming the contribution of atmospheric CO_2 to what is known today as "greenhouse effect." Arrhenius (1896) speculated that long-term climate variations were correlated to varying concentrations of CO_2. In 1938, British engineer Guy Callendar confirmed Arrhenius' speculations in that warming effects had already begun as a result of increasing GHG emissions since the Industrial Revolution. Callendar (1938) recognized human-generated production of CO_2 from fossil fuel combustion was accelerating overall atmospheric CO_2 levels and predicted a 2° C increase in global mean temperatures would result from a doubling of CO_2 levels that existed in 1938.

Systematic data collection on atmospheric CO_2 content traces back to the late 1950s. Beginning in 1958, annual data from a climate monitoring station in Mauna Loa, Hawaii, led by Dr. Charles Keeling, has conclusively shown increasing concentrations of CO_2 (Scaife, Folland, & Mitchell, 2008). Dr. Keeling graphed initial samples to produce the "Keeling Curve;" a line graph that depicts changes in atmospheric CO_2 (Figure 2.1). From 1958 to 2018, CO_2

concentration has increased from 96 parts per million (ppm) to 411 ppm (NASA, 2019). The National Oceanic and Atmospheric Administration (NOAA) asserts that atmospheric CO_2 had not surpassed 300 ppm in the past 800,000 years (Lüthi et al., 2008). The Keeling Curve prompted a wave of scientific interest and growth, which led to international attention and political involvement regarding CO_2 emissions reduction (Bodansky, 2001).

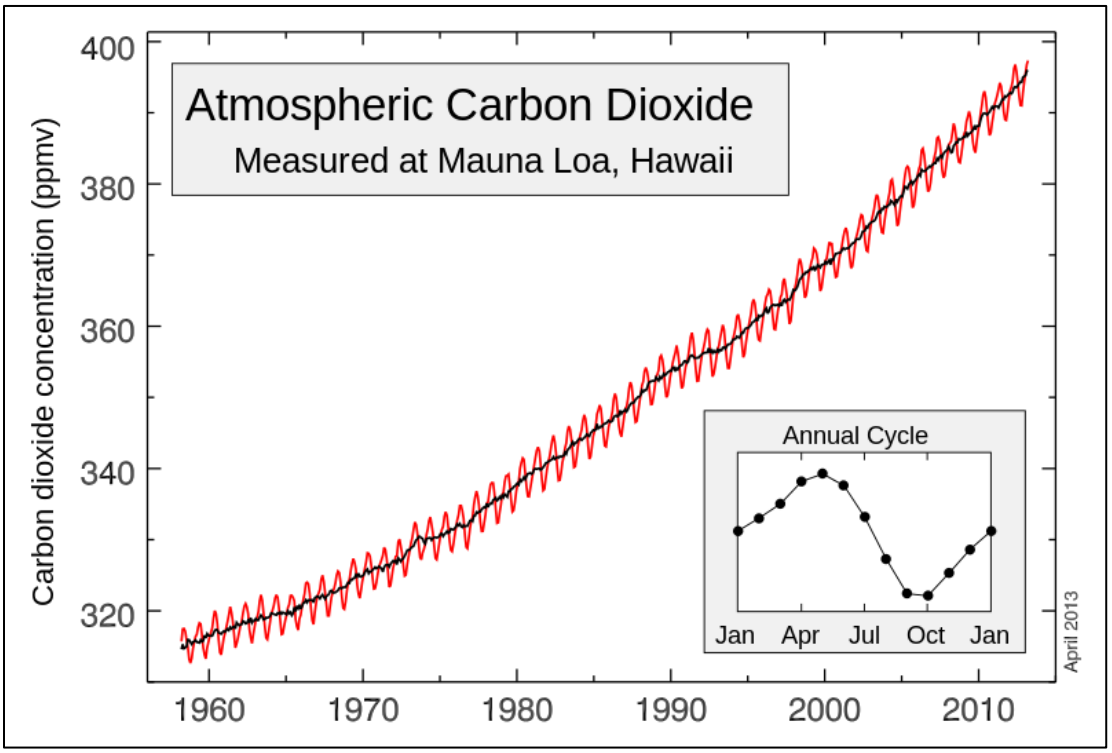

Figure 2.1. The "Keeling Curve" capturing a rise in the atmospheric concentration of CO2 over time (Image by Narayanese, Semhur, and National Oceanic & Atmospheric Administration, retrieved from Kim, 2018)

2.1.2. International Climate Change Policy: 1979-1996

The first gathering to frame and discuss climate on a global scale was in 1979 at the World Climate Conference, held in Geneva, Switzerland, called to order by a collaboration of "experts on climate and mankind." Participants included the World Meteorological Organization (WMO), International Council for Science, United Nations Environmental Program (UNEP),

World Health Organization, and other scientific partners representing the 53 attending countries (Zillman, 2009). With no supranational authority in place to monitor climate change, a World Climate Program (WCP) was proposed to gather data and advance knowledge of climate systems. Conference proceedings urged nations to foresee and prevent potential human-made changes that might be adverse to the well-being of humanity by establishing national climate programs under the guidance of the WCP (WMO, 1979).

In 1985, the International Conference on the Assessment of the Role of Carbon Dioxide and other Greenhouse Gasses in Climate Variations and Associated Impacts convened in Villach, Austria, known today as the Villach Conference. WCP data led the conference which concluded that the increasing concentration of atmospheric GHG emissions would increase the global mean temperature in the first half of the 21st century at a rate never experienced in the history of man (World Climate Programme, 1986). Climate change had transitioned from speculation into a plausible reality requiring mitigation and enhanced supervision in the form of a climate change framework.

The necessity for a framework was reaffirmed in Toronto in 1988. The conference, Our Changing Atmosphere: Implications for Global Security, set a 20% emissions reduction target from 1988 levels for developed countries by 2005 (WMO, 1989). In the same year, the Intergovernmental Panel on Climate Change (IPCC) was established to provide expert assessments on published scientific literature, every five years, while also assisting in national and international climate change negotiations. The panel's establishment was a significant step in advancing climate change knowledge and garnering both political and public interests (Bodansky, 2001).

The IPCC's first assessment report was released in 1990 and reviewed at the second World Climate Conference. Findings from the WCP and IPCC were similar in that human-induced emissions are increasing atmospheric concentrations of GHGs. The report confirmed that anthropogenic factors attributed to GHG concentrations in the atmosphere and global mean temperature would rise 0.3° C per decade in the 21st century if no means of emissions control were established (IPCC, 1990).

A global framework convention was created in 1992. One hundred fifty-five countries signed the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development, also known as the Earth Summit, in Rio de Janeiro. By convening annually at meetings known as the Conference of Parties (COP), the UNFCCC has worked toward stabilizing atmospheric GHG concentrations since the first COP in 1995 (United Nations, 1992). During 16 years of progress after the initial World Climate Conference, a foundation was formed to study, monitor, and internationally negotiate mitigation strategies of GHG emissions and climate change.

2.1.3. International Climate Change Policy: 1997-Present

The first global agreement to reduce emissions was established in 1997 during COP-3 in Kyoto, Japan. Known as the Kyoto Protocol, the agreement drew from the IPCC's Second Assessment Report from 1996, amongst other advising bodies to set international GHG reduction commitments, subject to ratification of signing parties. The protocol established individual targets for industrialized and developing countries based on differentiated emission outputs, known as Annex I and non-Annex I, respectively (Hulme, 1998). Annex I parties were to collectively reduce GHG emissions by an average of 5.2% from the 1990 baseline during a 2008-2012 commitment period. Non-Annex I parties complied voluntarily while developing national

infrastructure to accommodate population growth (UNFCCC, 1997). Kyoto defined six GHGs that count toward parties' emission reduction targets: CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Proper implementation required 55% of parties to ratify the protocol by 2005, including enough Annex I parties to account for at least 55% of the group's total emissions. The Kyoto Protocol entered into force in 2005 with 184 ratifying parties, including the entire EU (EPA, 2019). The US withdrew in 2001 and was not subject to meeting a reduction target.

With the Kyoto Protocol's first commitment period beginning in 2008, expectations of a new agreement were hopeful for the 2009 COP-15 in Copenhagen, Denmark (Gupta, 2010). However, due to a global recession, the conference gained little to no ground and was considered a disappointment as no agreement was reached to extend or succeed the Kyoto Protocol. Few countries set voluntary emission reduction goals under no penalty or framework. An amendment was agreed upon at the COP-18 in 2012. An 18% GHG emissions reduction target was decided upon for Annex I countries to meet by 2020 in the Doha Amendment. This target was never enforced due to a lack of ratification (UNFCCC, 2019a).

A successor to the Kyoto Protocol and current prevailing global climate treaty was adopted in 2015 by 195 countries at COP-21 in Paris. The Paris Climate Accord entered into force in 2016; the accord currently has 184 ratified parties (UNFCCC, 2019b). The treaty did not recognize Annex I countries. Instead, it introduced a bottom-up approach which allows parties to make individual commitments to keep global mean temperatures well below 2° C from pre-industrial levels. Parties are to submit plans and updates every five years regarding compliance mechanisms, termed nationally determined contributions (NDC); the first of which

are expected by 2020. The US, under direction of President Donald Trump, withdrew from the Paris Accord in 2017.

2.1.4. Summary and the Path Forward

Climatic discoveries have accelerated since Foote's initial findings in 1856 on the warming effect of CO_2. Based on these discoveries and willingness of world leaders to negotiate emission treaties, a sense of environmental responsibility has been fostered throughout the globe. However, while international policy has been met with general consensus, world population growth, economic development, and energy use continue to drive GHG emissions. In the past half-century, the global population has increased from three to over 7.5 billion people, and the world's total primary energy supply has more than doubled while fossil fuel use proportionately increased to meet energy demands (IEA, 2019a). World energy consumption projections from the US Energy Information Administration predict a 28% increase in world energy consumption by 2040, and renewable energy is expected to be the fastest-growing source (Doman, 2017).

2.2. Political Drivers of the Wood Pellet Industry

2.2.1. Introduction

Concurrent to the development of international climate treaties, individual nations have established policy mandates under the goals of the UNFCCC to prevent what a consensus of scientific researchers have described as potentially disastrous climatic events (Deffenbaugh et al., 2017; Easterling et al., 2000; Lesk, Rowhani, & Ramankutty, 2016; Meehl & Tebaldi, 2004; Schleussner et al., 2015). Many tangible instances of climate change are already being experienced at the global level. Examples include accelerated melting of Artic ice mass (Rignot et al., 2011), record high monthly and annual global temperatures recorded in 2018-2019 in the 140 years of official government measurements (NOAA, 2019; WMO, 2019), threatened

extinction of floral and faunal species due to habitat degradation (Carpenter, 2008; Wiens, 2016), and elevated sea temperatures impacting marine life migration and habitat (Nagelkerken, & Munday, 2015).

Renewable energy has proliferated in recent years, mainly due to mandated use or subsidization in many of the world's electricity-generation sectors. Solar, wind, and hydropower are the leading sources of renewable energy. In addition, biomass, either agricultural or wood-based, has become a viable alternative to fossil fuels for energy generation. Technological advancements and economies of scale, due to increased use in these renewable energy sources, have created increasingly cost-efficient, competitive, and dependable alternatives to fossil fuels. The focus of this thesis, biomass energy in the form of wood pellets, has been a relatively recent phenomenon in global energy generation markets for electricity generation.

2.2.2. European Union (EU)

2.2.2.1. Policies

In 1996, the EU prepared for the 1997 COP-3 in Kyoto by adopting a position of a 15% emissions reduction by 2010 from the 1990 baseline. Before the conference, the European Commission published a white paper in 1997 titled *Energy for the Future: Renewable Sources of Energy*, where it set a non-binding target to utilize 12% RES in overall energy generation by 2010 (European Commission, 1997). As a compliance mechanism to the Kyoto Protocol, the 2001 EU Directive on Electricity Production from RES developed a framework to promote a renewable and low-carbon European economy. The directive set an overall 21% RES contribution target for electricity markets by 2010 (European Commission, 2001). In 2005, a Biomass Action Plan was released to reduce foreign dependence and high prices of fossil fuel by

increasing development, financing, and use of the EU's woody biomass for energy (European Commission, 2005).

At the end of the Kyoto Protocol's first period, the EU-15 reached a 11.7% GHG emissions reduction, exceeding the 8% commitment; 12 new member states that had joined by 2007 attributed to the EU-27's overall 19% reduction in emissions from the baseline year of 1990 (European Commission, 2017). However, in terms of the 2001 directive, 2008 EU electricity generation consisted of 16.6% RES, nearly a fifth of which was attributed to biomass (European Commission, 2009b; Roubanis, Dahlstrom, & Noizette, 2010).

EU Parliamentary debates over a successor to the 2001 directive resulted in the adoption of a legally binding policy in 2007. The Renewable Energy Directive (RED) was enacted in 2009 and set an EU-wide target of 20% renewable energy production by 2020 while calling for member states to create national renewable energy action plans to report measures for compliance (European Commission, 2009a). The European Commission was tasked to monitor member states' progress and compliance with the directive's bioenergy sustainability criteria. The criteria take into account outside sources of biomass to ensure sustainability in their environment of origin. Examples of these criteria include forbiddance of biomass extracted from primary woodlands, wetlands, and highly biodiverse areas with minimal or no human activity. In 2015, the sustainability criteria of the RED were amended to mitigate the effects of indirect land-use change, which have implications for food security and community stability (European Commission, 2015).

The RED is part of a broader EU initiative known as the Energy and Climate Change Package, with objectives to reduce GHG emissions by 20% from the 1990 baseline, utilize 20% RES in energy production, and improve energy efficiency by 20%, by 2020. The package also

includes the Directive on emissions trading, the Effort-Sharing Decision, and the Directive on carbon capture and storage. According to 2017 EU renewable energy progress reports, member states collectively achieved a 16% share of energy from RES in 2014 and estimated to reach 17% by 2016 (European Commission, 2018a).

In December of 2018, EU Parliament released a recast version of the RED (RED II) with new binding targets of 32% overall renewable energy production and 15% renewable energy production in the electricity market for the period of 2021-2030 (European Commission, 2018b). Sustainability criteria received significant attention, as to address criticisms over carbon-neutrality concerns of solid biomass energy production and emissions accountability under prior EU policy (European Commission, 2019b). A new regulation was added to enhance criteria regarding origins of biomass used for RES targets. The Land-use, Land-use Change and Forestry regulation (LULUCF) included essential certification criteria such as sustainable harvesting, forest regeneration, and maintenance of long-term production capacity of forests, but also criteria for supplying countries' Paris Accord involvement. Article 29, paragraph seven of the RED II states, "(a) the country or regional economic integration organization of origin of the forest biomass: (i) is a Party to the Paris Agreement; (ii) has submitted a nationally determined contribution to the UNFCCC . . . (iii) has national or sub-national laws in place . . . applicable in the area of harvest, to conserve and enhance carbon stocks and sinks. . ." (European Commission, 2018b, article 29, paragraph 7, point a). In the case that these criteria are not met, countries or regions of origin must prove that management systems are in place to ensure carbon stock and sinks in forests are maintained or enhanced (European Commission, 2018b). As with the RED, the RED II is part of a larger package of legislation known as Clean Energy for all

Europeans, a compilation of eight policies in an attempt to form an energy union within the EU (European Commission, 2019a).

2.2.2.2. Incentives and Subsidies

The RED and RED II incentivize compliance of renewable targets with monetary penalties in the case that member states do not meet individual targets. The directives enforce compliance of sustainability criteria by withholding eligibility for support schemes and subsidies. Support schemes and subsidies are laid out in member states' national renewable energy action plans, which include support for investment, support to production, and support to research and development initiatives. Support for investment includes tax credits, property tax abatement, grants, and other business tax incentives. Support to production includes subsidies such as feed-in tariffs (FIT), feed-in premiums, and renewable energy quotas with tradeable certificates. Total energy support amongst member states in 2012 was $160 billion, including $20 billion in EU level support from the EU structural and cohesion funds as well as European Energy Program for Recovery (Alberic et al., 2014). A majority of subsidy funding, $77 billion, was utilized for support to production; 56% spent on FITs to incentivize renewable energy production within the power sector.

2.2.3. The United Kingdom

2.2.3.1. Policies

Under the Kyoto Protocol, the UK committed to a 12.5% reduction in GHG emissions. Progress reported by the UK Climate Change Program, established in 2000, projected GHG savings to be 15% below 1990 levels by 2010 (UK, DETR, 2000). Ahead of the UK commitment deadline, Parliament reinforced emissions reduction by passing the Climate Change Act of 2008, making the UK the world's first country to set long-term and legally-binding

national legislation on GHG emissions (CCC, 2019). This act set a target of 80% reduction in GHGs recognized by the Kyoto Protocol by 2050 from the 1990 baseline (UK Parliament, 2008). The act plans to accomplish the target by incrementally setting five-year periods with a cap on allowed emissions output called "carbon budgets." The budgets are set 12 years in advance to allow for adoption by the government and society in general; the UK is currently in the third budget period of 2018-2022. The act also established a Committee on Climate Change (CCC) as a statutory adviser to report annually on progress and assist in creating carbon budgets. The 2018 CCC Progress Report highlighted a decade of progress in which a 43% GHG reduction was achieved compared to 1990 levels. Since 2012, 75% of the emissions reduction was attributed to the electricity generating sector, reflecting a decrease in the use of coal-powered generation that renewable-powered generation has replaced (CCC, 2018).

2.2.3.2. Incentives and Subsidies

Incentives for large-scale electricity production (>5 MW) include the Renewables Obligation scheme (RO) and Contract for Difference (CfD). The RO scheme was enacted in 2002 and requires energy providers to source an annually increasing proportion of production from RES, which is set by the UK Department of Business, Energy, and Industrial Strategy (Ofgem, 2017). For every megawatt-hour (MWh) an energy provider produces using RES, a Renewables Obligation Certificate (ROC) is granted by the government, which can be purchased by energy providers lacking RES technology to remain in compliance of the RO scheme. If ROs are not met, companies pay the penalty referred to as a "buy-out price," which is the price of the appropriate amount of missing ROCs for compliance. For coal-burning energy generators, the RO scheme presented a platform to recollect capital from transitioning their facility to utilize RES. The program ended in March of 2017 to new facilities, but previously participating

companies were grandfathered in and will continue to receive and sell ROCs until 2027 (UK Parliament, 2015).

In 2014, the CfD scheme began replacing ROs as the primary mechanism to support new investments in renewable energy generation (BEIS, 2019). The CfD scheme involves a contract between an energy provider and the national Low Carbon Contracts Company, owned by the Department of Business, Energy, and Industrial Strategy. The Low Carbon Contracts Company pays energy providers the difference between RES electricity generation cost and average market price for electricity over 15 years.

2.2.4. Japan and South Korea

2.2.4.1. Policies

New pellet demand from East Asian markets has emerged due to recent policy adoptions in Japan and South Korea. Much like the UK, Japan and South Korea are densely populated and contain a limited amount of domestic natural resources, forcing the nations to depend on imports for energy.

In recognition of Japan's resource dependency, the Japanese Ministry of Economy, Trade, and Industry (METI) enacted the Basic Act on Energy Policy in 2002. The act established a framework to promote energy supply and demand measures on a long-term, comprehensive, and systematic basis known as a "Strategic Energy Plan" (METI, 2002). Plans are formed every four years and present a basis for the orientation of new policy by providing viewpoints on energy security, environmental sustainability, economic efficiency, and safety. In 2010, Japan enacted the National Plan for the Promotion of Biomass Utilization, which set targets for usage rates of different biomass sources and developed technologies for biomass utilization (Thrän et al., 2017). In 2015, the METI released the Long-term Energy Supply and

Demand Outlook, which presented an ideal energy mix for 2030 including 22-24% RES (3.7-4.6% biomass), 20-22% nuclear, 27% natural gas, 26% coal, and about 3% oil (METI, 2015).

Japan responded to the Paris Accord in 2015 by submitting an NDC of a 26% reduction in GHG emissions by 2030 from the 2013 baseline (METI, 2018). The fifth Strategic Energy Plan, released in 2018, evaluated and strengthen measures toward this 2030 goal, and declared intent to achieve de-carbonization by 2050 (METI, 2018). The efficiency of existing coal-firing power generation plants is expected to be a minimum of 41% by 2030; as part of the voluntary effort to phase out coal by 2050. Power stations are allowed to subtract power generated by wood pellets from total power utilized for production, therefore increasing their calculated efficiency (Strauss, 2017a).

Similarly, in South Korea, the Act on the Promotion of the Development, Use, and Diffusion of New and Renewable Energy was established in 2004 as a framework to decrease dependence on resource imports for energy and promote utilization of new renewable energy sources (MoTIE, 2015). An amendment established in 2010 created enhanced planning mechanisms called "Master Plans," which are updated every five years, and an annual "Basic Plans" to achieve objectives of master plans. Under the fourth Basic Plan of the first Master Plan, South Korea set a RES utilization target of total energy consumption at 11% in 2015 to be met by 2035 (MoTIE, 2014). Also, in 2015, South Korea responded with an NDC of 37% GHG emission reduction to Paris Accord (Export.gov, 2018). In 2018 under the second Master Plan, the eight Basic Plan enhanced the 2015 RES target to 20% by 2030 (MoTIE, 2017).

2.2.4.2. Incentives and Subsidies

Japan has subsidized renewable energy since 2012 using long-term FITs. Under the FIT scheme, electric utilities and merchants are obligated to buy a certain amount of electricity

generated from RES under a 10 to a 20-year contract, at a fixed price; the government then issues levies on consumers to allocate funds toward support for new RES development (METI, 2012). The scheme was partially amended in 2017 to adjust purchase prices and contract lengths for different electrical output capacities and sources of renewable energy (IEA, 2019b). For instance, wood pellet utilizing power stations receive a 20-year FIT, but pellets composed of forest residues receive a higher contract price than those composed of solid wood.

Unlike Japan, South Korea is heavily incentivized to produce renewable energy by Renewable Portfolio Standards (RPS), which replaced the Korean FIT scheme in 2012 (Strauss, 2017a; KEA, 2019). RPS is very similar to the UK RO scheme and mandates the 21 largest electricity-generating companies in South Korea, with a capacity of 500 MW or more, to produce a proportion of electricity output from RES, or purchase enough Renewable Energy Certificates (REC) to fulfill their obligation. Obligations increase from 2% in 2012 to 10% by 2022; the obligation is 7% for 2019 (Export.gov, 2018; KEA, 2019). Biomass is expected to contribute 50-60% of the electrical capacity obligated by the RPS (Thrän et al., 2017). The penalty for non-compliance of RPS is a maximum of 150% of the trading price for missing RECs.

CHAPTER 3. AN OVERVIEW OF THE WOOD PELLET INDUSTRY

3.1. Wood Pellet Demand

3.1.1. Global

The wood pellet industry is divided into two markets, the non-industrial or heating market, and industrial market. Non-industrial market demand is attributed to pellet applications in commercial and residential heating such as boilers and stoves. Industrial market demand derives from power stations substituting coal with pellets to produce energy for national, regional, or local grids. Over the past 10 years, global markets have drastically increased as more countries incorporate climate change policy and incentivize both production and consumption of wood-based biomass pellets. Growth of the industry in supplier countries coincides with demand developments in the industrial market.

Of the overall global wood pellet sector, the industrial market share in 2010 was 38%, and by 2016 rose to 50%; it is forecasted to continue increasing to 63% by 2025 (Figure 3.1) (Strauss, 2017a). By 2025, the global industrial market is expected to reach 43 million metric tons (MMt), of which 22 MMt will be consumed in Europe (Figure 3.2) (Strauss, 2017b). Growth in global pellet trade rose 19% in 2013, year over year, then declined to 7% in 2014 and 2015 (Walker, 2018). As EU and East Asian markets grew, new power station construction was planned, and conversions and new stations came online, resulting in global trade to recover and expand (Figure 3.3). In 2017, trade increased by 13% to 18.9 MMt, and then 26% to 23.8 MMt in 2018 (Walker, 2018).

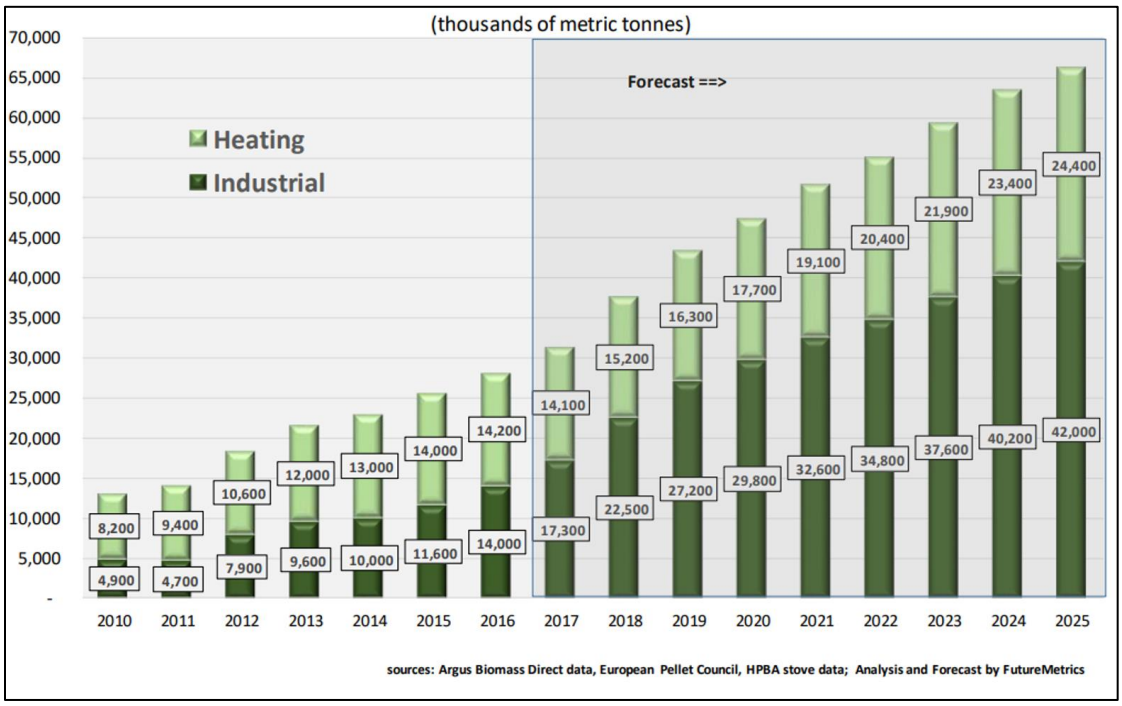

Figure 3.1. Global heating and industrial wood pellet demand 2010-2025 with forecasted 2017-2025 in thousands of metric tons, provided by FutureMetrics (Strauss, 2017b)

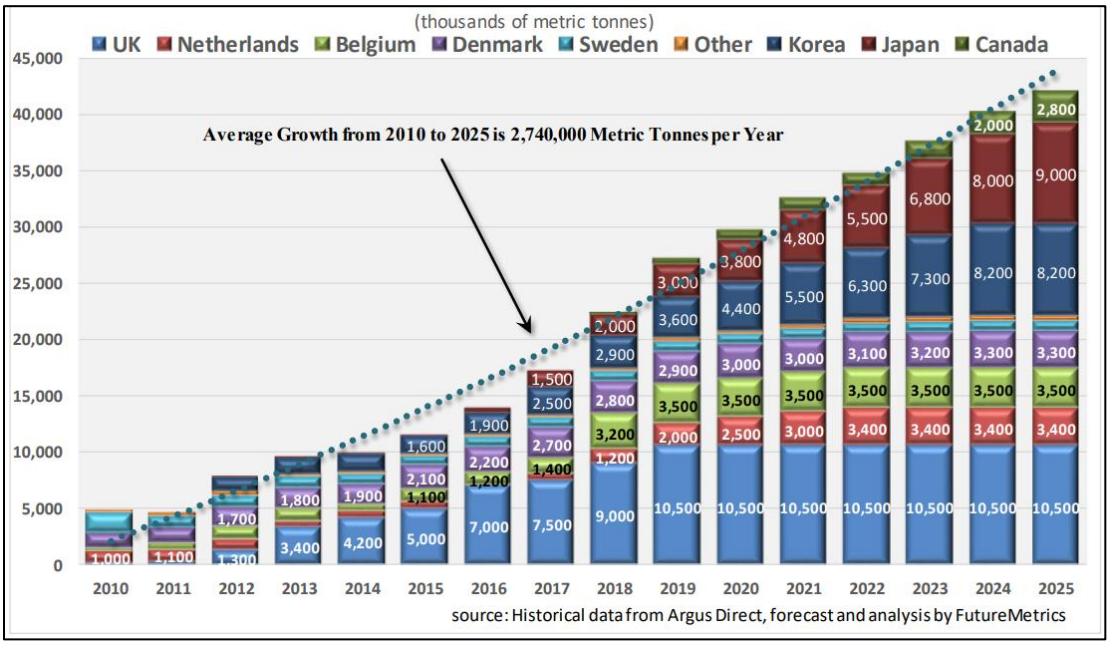

Figure 3.2. Industrial wood pellet demand 2010-2025 for Europe, the UK, Korea, Japan, and Canada in thousands of metric tons, provided by FutureMetrics (Strauss, 2017b)

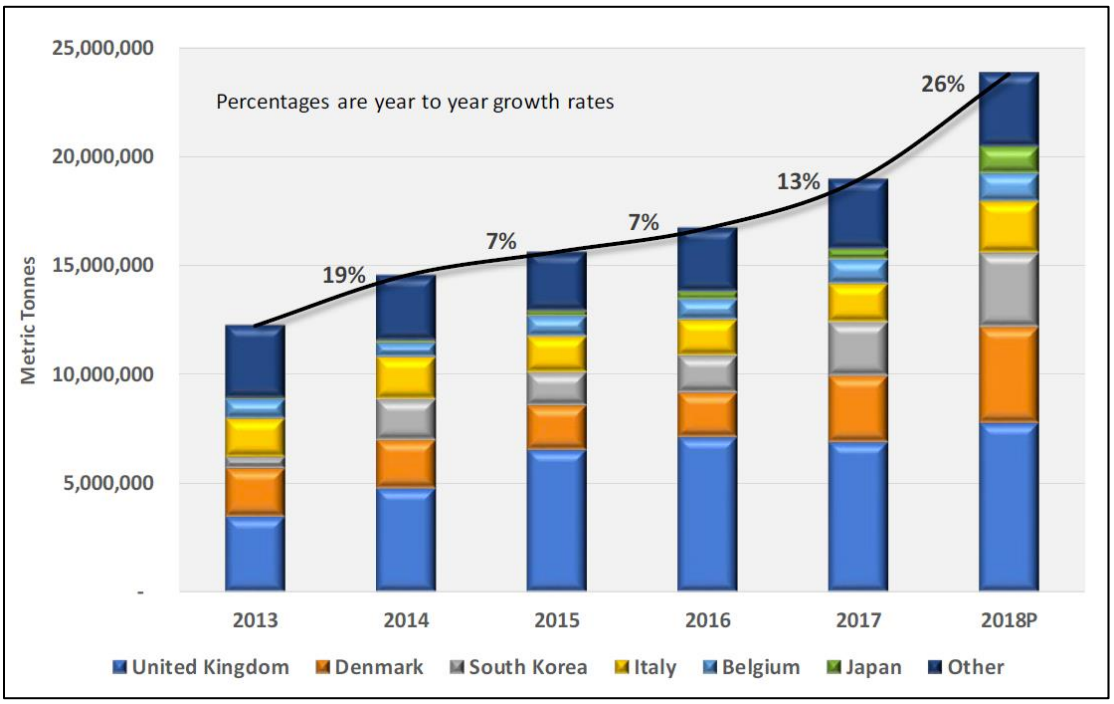

Figure 3.3. Global pellet imports 2013-2018 from the UK, Denmark, South Korea, Italy, Belgium, Japan, and other major demand countries in metric tons, provided by FutureMetrics (Walker, 2018)

3.1.2. European Union

European industrial pellet demand increased at an average rate of 11.5% per year since the implementation of the RED in 2009. In 2017, the EU-28 consumed 24.1 MMt, around 75% of global consumption (Flach, Lieberz, & Bolla, 2019). In 2018 the EU-28 consumed 27.35 MMt (Flach et al. 2019). Consumption in 2018 represented 118% increase in demand since 2011. The EU imported 8.7 MMt of pellets in 2017, of which 5.2 MMt were imported from the US (Flach et al., 2019). In 2018, European imports rose to 10.35 MMt, of which 6.1 MMt were imported from the US (Flach et al., 2019). Estimates for 2019 indicate an increase in consumption to 30 MMt, and imports to 12.2 MMt (Flach et al., 2019).

The UK, Italy, Denmark, Germany, and Sweden consumed eight, 3.75, 3.5, 2.2, and 1.8 MMt, respectively (Flach et al., 2019). Consumption in Germany and Italy is primarily non-

industrial. However, consumption in Denmark, Sweden, Belgium, the Netherlands, and the UK is primarily for energy production and contribute toward policy targets. Denmark, the UK, the Netherlands, and Belgium are the major importing countries, and the EU wood pellet market is expected to continue growing. However, further expansion may be limited by the sustainability criteria imposed by individual member states.

3.1.3. Denmark

Roughly 70% of wood pellets consumed in Denmark are utilized for energy production in combined heat and power (CHP) plants (Thrän et al., 2017). Denmark is the second-largest importer of pellets, importing chiefly from the Baltic Region. Since 2011, Danish demand has risen an average 12.3% per year, mainly in part by conversions from Danish utility company Ørsted. Ørsted has utilized biomass in its power plants since 2002. The company's 757 MW Avedøre power station began co-firing pellets in 2003 and fully converted to operate on pellet fuel in 2014. In 2009, Ørsted's 88 MW Herning power station was rebuilt to utilize 30% pellets and 70% wood chips. Avedøre's first boiler and a boiler in Ørsted's Studstrup power station were both fully converted to operate on wood pellets in 2016, which largely contributed to a 25% increase in Danish consumption and a 50% increase in 2017 imports to 3.1 MMt (Flach et al., 2018; Walker, Strauss, Swaan, & Schmidt, 2018). Ørsted has reduced its dependence on coal from 6.2 MMt in 2006 to 1.7 MMt in 2016 and plans to stop use by 2023 entirely (Ørsted, 2019).

3.1.4. The United Kingdom

The UK is the world's leading consumer of wood pellets. The country is attributed with the most significant increase in demand from 2012 to 2018, at 471% (Flach et al., 2019). This increase is a direct result of power plant conversions, particularly by the Drax Group. The Drax Group owns the largest power station in the UK and Western Europe; located in Shelby, North

Yorkshire, Drax produces 7% of UK electricity. Initially, the power station consisted of six coal-burning generators with a 3,960 MW energy capacity strategically constructed next to the Shelby coalfield. In 2013, Drax converted the first of four generators to run on pellet fuel. In 2016, Drax announced that 70% of the company's energy was produced from wood pellets, which accounted for 20% of UK renewable energy (Drax, 2019). Each of the four converted units can burn 2.3 MMt per year, consequently increasing UK pellet demand (Table 3.1) (Flach et al., 2018).

Table 3.1. Timeline of Drax's pellet-firing unit conversions, UK wood pellet consumption, and percent change in UK wood pellet consumption, year over year (Data from Drax, 2019 & Flach et al., 2019)

Year	2011	2012	2013	2014	2015	2016	2017	2018
Drax Conversion			Unit 2	Unit 3		Unit 1		Unit 4
UK Pellet Consumption (MMt)	1	1.4	3.7	4.9	6.7	7.3	7.4	8
Change in Consumption	N/A	40%	164%	32%	37%	9%	1%	8%

Two other large power stations will continue to drive UK demand beyond 2018. Conversion of Lynemouth's 396 MW power station and commissioning of MGT's Teeside 299 MW CHP will add 1.4 and 1.5 MMt to demand (Walker et al., 2018). Lynemouth power station's conversion was completed in 2018 with full production beginning in 2019, and Teeside CHP is expected to come online in 2020.

3.1.5. Belgium and the Netherlands

The Dutch countries of Belgium and the Netherlands contribute to wood pellet demand almost entirely through industrial markets. Belgium imports over 75% of demand from non-EU sources; mainly the US and Canada (Flach et al., 2019). Belgium has two pellet-firing power stations, Engie Electrabel's 80 MW Les Awirs and 205 MW Max Green (Walker, 2018).

Belgian pellet demand has remained relatively consistent with an average growth rate of 4.2% since 2011. However, the Netherlands has experienced significant fluctuations.

In 2010, the Netherland's co-firing power plants made the nation the largest industrial pellet market (Walker, 2018). By 2012, the nation consumed 1.2 MMt of pellets, which decreased to 0.5 MMt in 2014 and 0.12 MMt in 2015. This decrease was a result of 2012 enhancements in sustainability criteria for the nation's feed-in premium subsidy, which hampered pellet sourcing (Flach, 2019). Power companies RWE, Uniper, and Engie managed to secure subsidies under the enhanced scheme in 2016 (Walker et al., 2018). RWE's 600 MW Geertruidenberg and 250 MW Eemshaven power stations will both co-fire pellets by 2018 and 2019, respectively; Uniper's 272 MW and Engie's 74 MW Rotterdam power stations will be co-firing pellets by 2020 (Flach, 2019). Together, these four power stations will be able to burn 3.3 MMt of pellets annually and will be the source of demand growth in the Netherlands.

3.1.6. Japan and South Korea

East Asian markets are expected to contribute to the majority of industrial pellet demand growth after 2019 (Strauss, 2017a). Since the implementation of Japan's FIT scheme, 84 biomass power plants have been approved for funding, and additional consideration has been given to over 100 more projects (Thrän et al., 2017). The 20-year term of FITs allows Japanese consumers to purchase long-term supply contracts with other countries. From 2012 to 2017, Japanese imports grew 600% from 71,981 Mt to 506,353 Mt; the country imports 80% of consumption from Canada and 11% from Vietnam (Iijima, 2018). To remain compliant with minimum generation efficiency requirements, 22 Japanese coal-firing power stations, producing over 200 MW, have announced intentions to co-fire wood pellets. One report reveals utilization rates of 1%, 5%, and 15% wood pellet mix in co-firing by these 22 stations have demand

potentials of 0.8, 3.9, and 11.7 MMt per year, respectively (Strauss, 2017a). However, Japanese demand by 2025 is estimated to be 9.5 MMt; half from co-firing power stations and a half from dedicated wood pellet power stations (Walker et al., 2018).

South Korean companies under the RPS are contributing to a steadily increasing demand. Imports grew 31%, 1.8 MMt to 2.4 MMt, from 2014 to 2017; 90% of 2017 imports were from Southeast Asian countries, mainly Vietnam (Forest2Market, 2018). The country has become the world's third largest wood pellet market and is expected to continue growing (Walker, 2018). Unlike Japan, South Korean buyers purchase pellets on a short-term basis due to uncertainty towards the value of tradeable RECs and a public tendering procurement system for fuels; the tendering system is used as part of an anti-corruption measure (Walker et al., 2018). Recent announcements from Canadian producers negotiating with Korean buyers may be an indication of more long-term supply contracts with western countries in the future.

3.2. Wood Pellet Supply

3.2.1. Global

Trends in wood pellet supply have followed the upward trend in consumption. Since 2011, the industry has grown at an average rate of 14% per year (Thrän et al., 2017). Global production was estimated between six and seven MMt in 2006, which doubled to 14.3 MMt in 2010. By 2015, global production was over 26 MMt, of which more than one third was internationally traded. At the end of 2018, global production was estimated to be 36 MMt. The US, Canada, and Germany are the world's largest pellet producing countries. Global production, imports, exports, and consumption for 2015/ 2016 are illustrated in Figure 3.4, which are proportionately comparable to the current landscape.

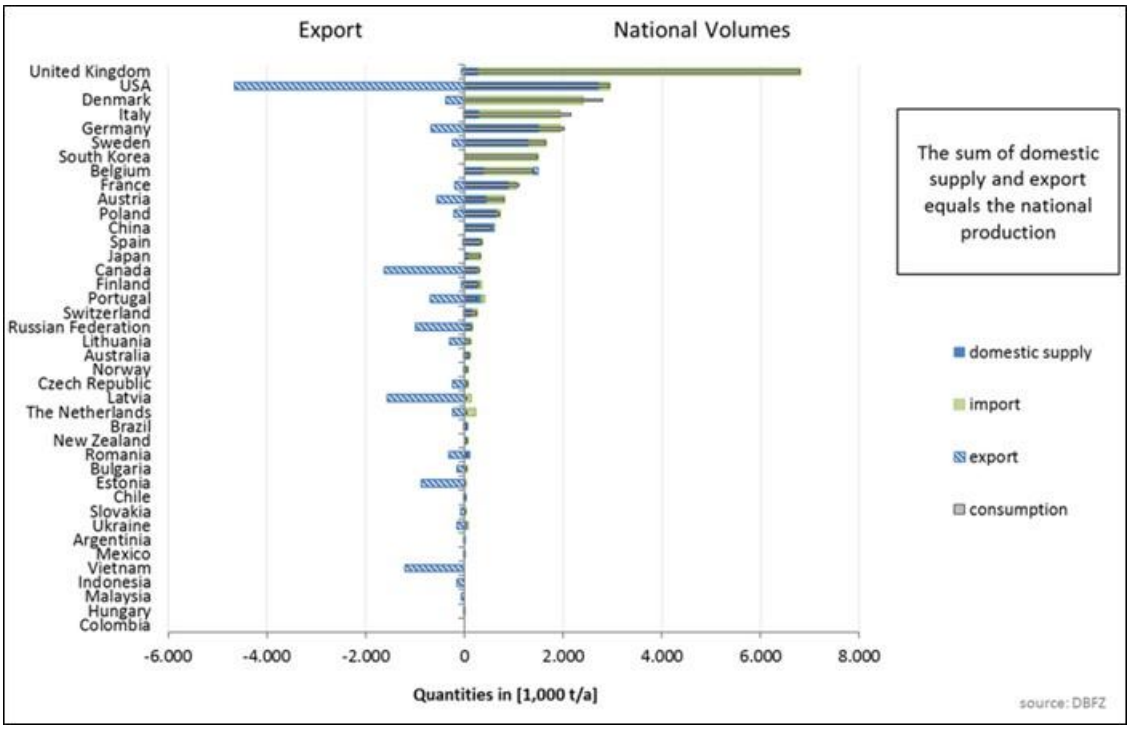

Figure 3.4. Domestic wood pellet production, imports, exports, and consumption per country in 2015/2016; sorted by consumption, provided by IEA Bioenergy Task 40 (Thrän et al., 2017)

Europe is not only the largest consumer of wood pellets, but it is also the most significant regional producer, accounting for around 50% of global production in 2018 (Flach et al., 2019). Germany, Sweden, and Latvia lead EU production with 2.4, 1.8, and 1.57 MMt produced in 2018, respectively. Although Russia contains a higher production capacity than Germany, Germany is the largest producer of European pellets and the world's third-largest producer due to the country's high non-industrial utilization rate (Flach et al., 2019). Sweden is the third-largest producer in Europe, but does not heavily export nor rely on imports; the country fluctuates between 70% and 90% self-sufficiency in supplying domestic demand (Flach et al., 2018). However, in terms of exports, Canada, followed by Latvia and Vietnam, are second, third, and fourth to the US (Thrän et al., 2017).

Emerging supply countries such as Vietnam are developing pellet infrastructure coinciding with existing wood product industries. As mentioned earlier, Vietnam is a significant supplier of wood pellets to East Asian demand countries. Supply rates, similar to consumption rates, depend on the favorable establishment of policy, subsidies, and incentives that assist in the stages of production. As the world's largest producer and for purposes of this thesis, the US pellet manufacturing industry will be the focus of this supply analysis.

3.2.2. The US Wood Pellet Manufacturing Industry

3.2.2.1. US Industry Origins

Wood was the primary source of energy for cooking, heating, and light in the US until the mid-1800s. The vast majority of firewood was used for heating, but wood also performed mechanical work in steam engines. Railroad use of fuel wood peaked at 3% of overall wood use in 1860, when wood represented 90% of locomotive fuel (White, 1979). Wood for all steam power (railroads, steamboats, and industry) was about 5% of total wood consumption in 1860 (Dewhurst, 1955). Wood was also burned to produce charcoal for iron smelting (about 100 million cords), and lumber waste was burned for power by sawmills (about 550 million cords) (Reynolds and Pierson, 1942).

The decline in wood use began after the onset of the Industrial Revolution. Mined coal became a convenient, more energy-dense fuel source for generating electricity. Oil and natural gas discoveries quickly replaced wood as the primary source of energy for internal combustion engines.

Aside from the historical use of wood pre-Industrial Revolution, more recently, a renewed interest in wood has emerged due to disruptions in fossil fuel markets and prices in addition to significant interest in alternative renewable energy sources (Spetler & Toth, 2009).

Oil energy crises throughout much of the 1970s prompted the modern origins of wood pellets for home heating and industrial applications (Lisle, 2013). An oil embargo imposed by members of the Organization of Arab Petroleum Exporting Countries (OPEC) in 1973 and the Iranian Revolution in 1979 caused oil supply shortages and rapid oil price inflation, which in turn, led to increased interest in alternative, renewable energy sources, including wood.

Inventor and business entrepreneur Rudolf Gunnerman patented his pelletizer for the production of wood pellets in 1977. The densification of wood fiber into pellets inherently creates a higher energy density combined with lower moisture content, which allowed wood pellets to be more easily transported in bulk versus conventional chips or briquettes (Hitchner, Schelhas, Hujala, & Brosius, 2014). Gunnerman's technology was first used in the Northwest and Northeast regions of the US, for pellet production supplying commercial boiler and residential stove heating markets. Early US companies, Western Power (1978-1982), Day Resources (now Lignetics), Biomass Energy, Guaranty Fuels, and Aspen Fibre, were the first to utilize this technology for a combined seven mills during the early 1980s (Kutney, 2016).

Wood comprised 10% of US residential energy consumption in 1982, a 6% increase since the first oil crisis of 1973, but as oil prices stabilized and new technologies for heating were established, consumption decreased to 6% in 1991, then 4% by 1997 (Song, Aguilar, Shifley, & Goerndt, 2012). By the mid-1990s, expansion of US natural gas extraction led to it eventually becoming a more widely-used and lower cost fuel alternative compared to wood pellets in domestic markets. In 1991, pellet consumption was 250,000 tons per year; primarily consumed in residential home heating markets (Miles & Miles, 1992). With less than a dozen commercial manufacturers, the US pellet industry did not experience much development until the mid-1990s as the global energy landscape began to change.

As a means to bring consistency to pellet production, in 1995 the Pellet Fuels Institute (PFI), a non-profit organization incorporated in 1985, introduced the first nationally recognized pellet standards to the growing US pellet industry. These standards established criteria for premium (residential) and standard (industrial) grade wood pellets, which were quickly adopted by the pellet manufacturing industry (Spetler & Toth, 2009). At the turn of the 21st century, EU foreign policy sparked a new paradigm in demand for industrial pellets which, in turn, prompted rapid investments in the US pellet industry. Since 2004, US pellet production to meet export demand increased dramatically, particularly in the South.

3.2.2.2. US Wood Pellet Production

Although domestic timber inventory is only 10% of the Earth's total, 96% of US consumption of industrial wood comes from domestic supplies. The US has 766 million acres of forestland, of which timberlands, forests available for forest products, comprise 514 million acres (Oswalt et al., 2014; Oswalt, Smith, Miles, & Pugh, 2018). As a means to remain consistent between the presentation of regional forests resource data provided by the US Forest Service (USFS) and regional pellet data, the regions recognized by the US Energy Information Administration (EIA) are used. The Eastern region is comprised of the USFS North region, the Western region is comprised of both the USFS Rocky Mountain and Pacific Coast regions, and the Southern region remains consistent with the USFS South region. The three regions are presented in Figure 3.5. The Southern region, which is commonly referred to as the nation's "Wood basket," contains almost half of the nation's timberlands at 40%, compared to 32% in the East and 27% in the West (Oswalt et al., 2018). In 2015, the South's forest product manufacturing sector accounted for 6% of US manufacturing gross domestic product (Jefferies,

2016). The Southern region also led the nation in industrial earnings in 2018, accounting for 33.9% of the four US census regions (Bureau of Economic Analysis, 2018).

A growing population and consumption of wood fiber have led to increasingly managed and productive timberlands in the US. From 1953 to 2015, acreage of timberlands increased at an average rate of 3% per year, annual timberland growth increased 112%, and annual removals increased by 57% (Forest2Market, 2017). As such, although removal rates increased, annual growth rates have exceeded removal rates since 1953 (Oswalt et al., 2018).

In 2008, the US produced 1.8 MMt of wood pellets and exported 0.49 MMt (Thrän et al., 2017). Exports rose to 1.9 MMt in 2012, and doubled by 2014 to 4.1 MMt; 98% of which was exported to the EU (Thrän et al., 2017). By 2015, production capacity had risen to 13.5 MMt, production increased to 7.4 MMT, of which 4.7 MMt were exported (Thrän et al., 2017); nearly 99% of 2015 exports were sent to the EU: 3.9 MMt went to the UK, 0.6 MMt to Belgium, and 0.06 MMt to the Netherlands. The 125 operational pellet mills in 2018 gave the US an operating capacity of 12.8 MMt (BBI International, 2018).

Although capacity had declined from 2015 to 2018, exports grew to 5.1 MMt in 2017 and then to 6 MMt in 2018; a 17% increase in exports and a 22% increase in total export value to $812 million, year over year (Greene, 2019). US Capacity in 2019 to date increased to 12.9 MMt with 125 operating wood pellet mills (BBI International, 2019). While BBI International (2019) presents the US operational capacity at 13.1 MMt for 2019, 200,000 Mt of capacity is attributed to agricultural waste and paper waste, and therefore not included in the wood pellet capacity presented in this thesis.

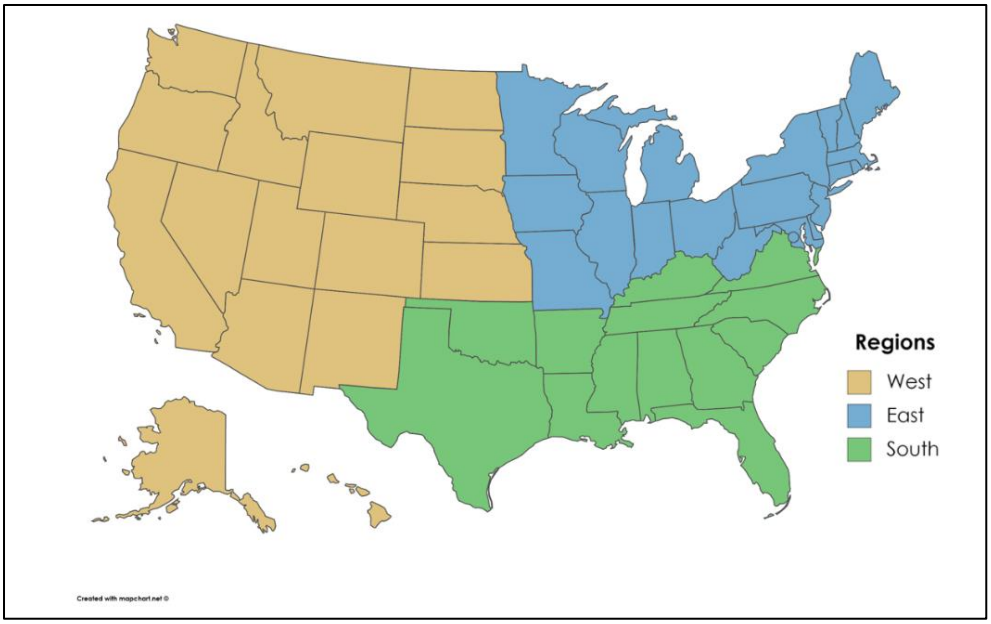

Figure 3.5. US regions and states within them (US Energy Information Administration regions)

Since 2011, the South has led the US in both wood pellet production and exports, accounting for 99.5% of total US wood pellet exports in 2017 (Abt, Abt, Galik, & Smog, 2014; US internal Trade Commission, 2018). The Southern region contains approximately 73% of the 12.9 Mt US operating capacity with 42 of the nation's 125 operating pellet mills for 2019 (Table 3.2) (BBI International, 2019).

Table 3.2. Wood pellet mill statistics for the three US regions (BBI International, 2019)

Region	South	West	East	Total
Operating Mills	42	27	56	125
Percentage of Operating Mills	33.6%	21.6%	44.8%	100%
Operating Capacity	9.4	1.1	2.4	12.9
Percentage of Operating Capacity	73%	9%	18%	100%
Idled Mills	2	4	1	7
Capacity of Idled Mills (MMt)	0.61	0.12	0.085	0.82
Mills Under Construction	1	1	1	3
Capacity of Mills Under Construction (MMt)	1	0.09	0.036	1.1

As a result of the concentration of pellet mills and production capacity, this thesis focuses on the Southern region. The region produced 5.5 MMt in 2017, a 5.2% increase from 2016, and exported 95% of production (Walker et al., 2018). Amongst the seven most significant companies in the US, six are based entirely out of the South and comprise 81% of the region's 2019 operating capacity (Table 3.3) (BBI International, 2019). A multitude of available shipping ports along the eastern seaboard and Gulf of Mexico allows the South to export 98% of all US wood pellets, which have become the third-largest exported wood product from the US (Goetzl, 2015).

Table 3.3. Seven largest US wood pellet manufacturing companies and capacities (BBI International, 2019)

Company	Operating Mills	Capacity (MMt)	Southern Capacity (MMt)
Enviva	7	3.4	3.4
Drax Biomass	3	1.6	1.6
Lignetics	12	0.87	0
FRAM Renewable Energy	4	0.96	0.96
RWE Innogy	1	0.75	0.75
Highland Pellets	1	0.6	0.6
Pinnacle	1	0.27	0.27
Total	29	8.45	7.58

3.2.2.3. Production Incentives

The US federal government does not significantly incentivize focused industrial use of wood pellets for energy generation relative to incentives for developing other renewable energy markets and technologies. Nearly half of all federal subsidies, 45% in 2016, were used to develop biofuel, solar, and wind renewable energy (EIA, 2018). Biofuel subsidies primarily assist the production of liquid biofuels such as ethanol and biodiesel (EIA, 2018).

However, these subsidies indirectly support the wood pellet manufacturing industry by providing financial support for forest feedstocks through the Biomass Crop Assistance Program (BCAP).

The BCAP was established by the US Department of Agriculture's (USDA) Food, Conservation, and Energy Act of 2008; commonly known as the Farm Bill. Since the initial implementation in 1933, the Farm Bill has been renewed every five years or so and stands as the country's primary food and agricultural policy program. The BCAP is implemented by the USDA's Farm Service Agency (FSA) in an effort to "…support the establishment and production of eligible crops for conversion to bioenergy in selected areas, and to assist agricultural and forest landowners and operators with the collection, harvest, storage, and transportation of eligible material for use in a biomass conversion facility" (Stubbs, 2011, para. 1). In order for commercial biomass conversion facilities to operate, a large-scale energy crop source must be available, including wood-based materials (FSA, 2010). The BCAP also works to improve US energy security, reduce carbon emissions, and stimulate rural economic development.

The BCAP support owners and operators of agricultural enterprises and non-industrial private forests by providing two categories of financial assistance: 1. Matching Payments; and 2. Establishment and Annual Payments (BCAP, 2019). The FSA makes matching payments to eligible owners and operators, who sell biomass to qualified conversion facilities, at a rate of $1 for each $1 per dry ton paid by the qualified facility. Limits under the 2008 Farm bill were a maximum of $45 per dry ton and a two-year payment duration. In 2016, four out of the 56 qualified conversion facilities under the matching payment category were wood pellet mills (FSA, 2016). The FSA makes establishment and annual payments to eligible owners and

operators who enter into a contract with the government-operated Commodity Credit Corporation. Owners and operators specify a certain amount of acres, within BCAP project areas, to receive up to 75% of the cost for establishing perennial crops, or annual payments if they establish annual crops. Annual payments for woody biomass crops last for up to 15 years, however, if a crop is sold for heat, power, or bio-based products, such as wood pellets, the annual payment is reduced by 25% (FSA, 2010).

In recent years, federal subsidies for renewable energy have declined significantly, in part by lower outlays for Renewable Electricity Production Tax Credits, which primarily act to benefit wind energy production (Figure 3.6) (EIA, 2018).

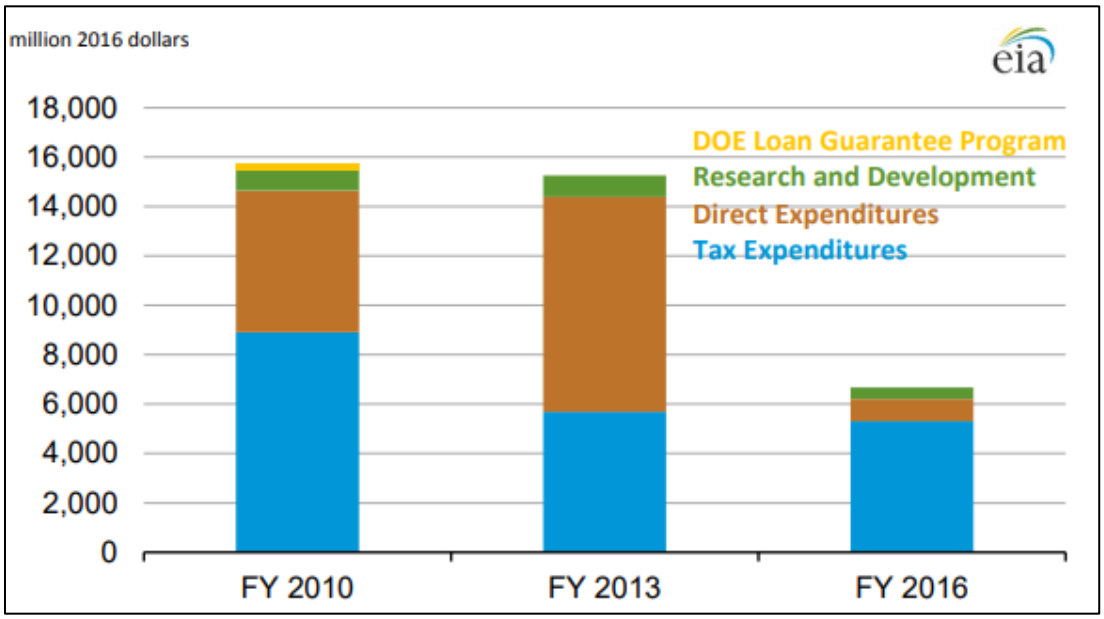

Figure 3.6. US Federal subsidies for renewable energy sources 2010-2016 in millions of dollars, including department of energy loans, research and development, direct expenditures, and tax expenditures (EIA, 2018)

The BCAP provided $269 million, $9 million, and $10 million in financial assistance for 2010, 2013, and 2016, respectively. The 2014 Farm Bill amended the initial $45 limit of the BCAP's matching payments category to $20 per dry ton (Karmen, 2014). Federal subsidies for

renewable-related direct expenditures overall decreased to $909 million in 2016 from the $8.7 billion provided in 2013 (EIA, 2018). Other USDA assistance programs regarding woody biomass, such as the Bio-refinery Assistance Program, Forest Biomass for Energy, and Community Wood Energy Program, did not provide any financial assistance during the 2010-2016 period (EIA, 2018). In spite of dramatic cuts in federal assistance, the wood pellet manufacturing industry in the US continues to expand, as economic development incentives and subsidies from individual states play a significant role in the establishment of new production facilities.

The South's proximity to EU markets, forest products infrastructure, and extensive supply of woody biomass make it a strategically desirable location to produce and export wood pellets. Geographic competition between Southern states has fostered the establishment of various economic development incentives to attract and retain businesses, and improve state and local economies. Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia offer a combined 464 economic development incentive programs across a diverse range of business sectors (CCER, 2019).

Incentive programs offered to both manufacturing and agribusiness industries attract wood pellet manufacturers with financial incentives to construct new or expanding facilities. Typical incentives are offered in the form of abatements, credits, exemptions, reductions, rebates, and refunds for sales and use taxes, real and personal property taxes, corporate income or payroll taxes, capital investments, port use, and job creation. States also can offer custom incentive packages to companies within competitive business environments.

For the purposes of this thesis, Table 3.4 lists incentives offered by Louisiana, Mississippi, North Carolina, South Carolina, and Virginia that are available to wood pellet manufacturers.

Table 3.4. Types of current tax incentives offered by Louisiana, Mississippi, North Carolina, South Carolina, and Virginia that are available to wood pellet manufacturers (✔ = Yes, ⃠= No)

State	Sales and Use	Real Property	Capital Investment	Job Creation	Port Use
LA	✔	✔	✔	✔	⃠
MS	✔	✔	✔	✔	⃠
NC	✔	⃠	✔	✔	⃠
SC	✔	✔	✔	✔	✔
VA	✔	✔	✔	✔	✔

3.3. Wood Pellet Supply Chains

In the US South, raw materials for wood-based pellet production are primarily sawmill residues, urban waste, logging residues (tree tops and branches), timber stand thinnings, and other trees that do not qualify for higher-value wood product markets (Dale, Parish, Kline, & Tobin, 2017). Diaz-Chaves, Walter, and Gerber (2019) have identified four main channels of feedstock sourcing: industrial wood producers, small landowners, wood product manufacturers, and timber contractors (Figure 3.7).

Feedstock is typically procured by a pellet company from one of these channels within a 50 to 75-mile radius and transported to a mill via truck or rail. At the mill, the feedstock is dried, ground, pelletized, cooled, and stored for transport. Pellets are then transported to shipping ports via truck or rail to be put on ships for transatlantic bulk export. The two largest US pellet producers, Enviva and Drax Biomass, store pellets in insulated domes at company-owned port facilities each with up to a 40,000 MT capacity. Once delivered to overseas ports, pellets are transported to power stations via truck or rail.

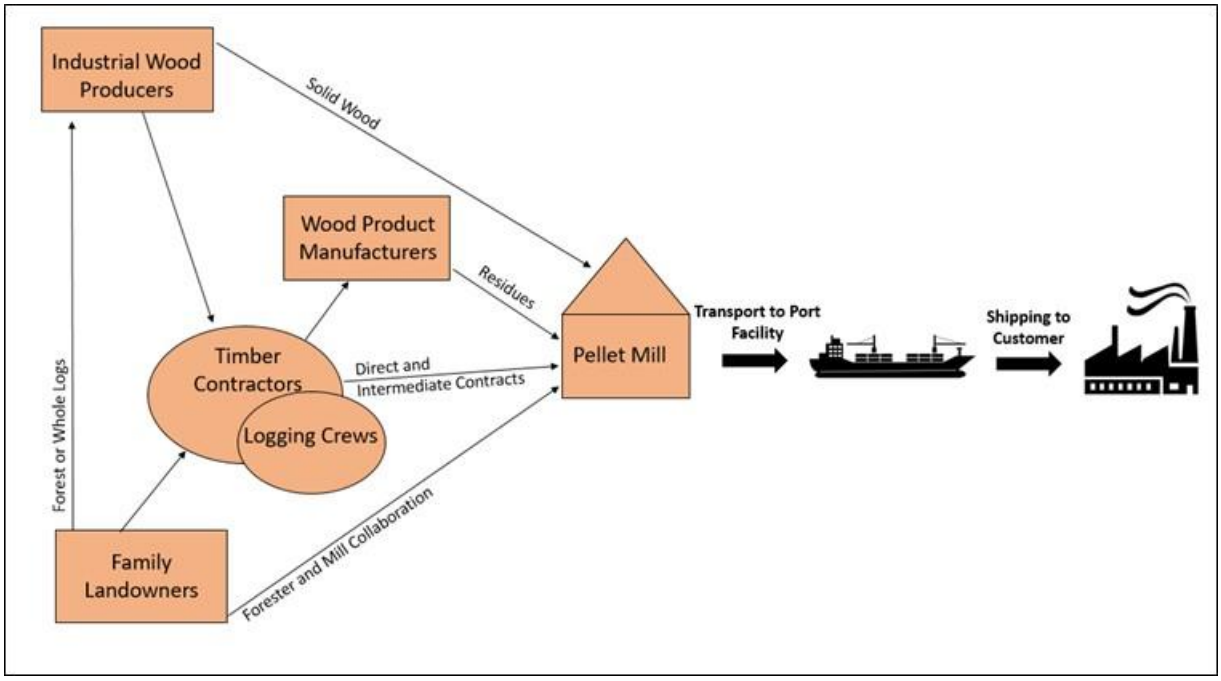

Figure 3.7. Wood pellet supply chain upstream and downstream of a pellet mill (Adapted from Diaz-Chavez, Walter, & Gerber, 2019)

CHAPTER 4. RESEARCH CONSTRUCTS AND FOUNDATION LITERATURE REVIEW

4.1. Business-Community Relationships and Perceptions of Natural Resource Development

4.1.1. Social License to Operate

Business-community relationships are defined by Steiner (1971) as businesses being social entities, or members of society that visibly operate and stimulate the economy. As members of society, the relationship between extractive industries (e.g. forest-based) and communities is dependent on perceptions of acceptance and trust, conceptually referred to as a "Social License to Operate" (SLO) (Gehman, Lefsrud, & Fast, 2017). Van Putten et al. (2018) defines the SLO as ". . . an informal contract between industry (or others) and communities that is awarded and maintained on the basis of transparent, ethical, and responsible use of natural resources, as perceived by community groups." Moffat, Lacey, Zhang, and Leipold (2015) argue that, "In many ways, the social license reflects the evolving nature of the relationships between industries and their communities and other stakeholders." The SLO has been a widely used concept within the mining industry, but has been increasingly adopted to explain business-community interactions and levels of acceptance toward other natural resource extraction operations.

Public trust and acceptance of natural resource extraction activities entail a level environmental, social, and economic responsibility expected from companies to earn an SLO. To this end, corporate social responsibility (CSR) is practiced by many extractive companies as a self-regulating business model, allowing companies to be socially accountable to stakeholders and other members of society. However, while CSR is rooted in industry and arises from a need to be socially accepted, the SLO is rooted in society and driven by beliefs and perceptions of

local communities; the SLO is recognized as a strategic CSR aspect of managing risk and opportunity (Moffat et al., 2015).

4.1.2. Rural and Urban Communities

Rural communities are often associated with marginalization due to insufficient public infrastructures, population decline, transitioning economics and demographics, and geographic remoteness (Bock, 2016). Rural communities are also associated with homogenous and under-developed areas, agricultural jobs, disadvantaged populations, low population density, and low social innovation. On the other hand, urban areas are defined by high population and building densities. Urban communities are associated with heterogeneous and developed areas, non-agricultural jobs, and high social innovation with sufficient public infrastructure.

In terms of the different social structure and interaction of rural and urban communities, social development theories proposed by the early sociological works of Émile Durkheim and Ferdinand Tönnies remain relatively appropriate today. Durkheim (1893) proposed two forms of social complexity, consisting of "mechanical" and "organic" societies. Mechanical societies contain a collective consciousness and similar social values while implying that individuals perform the same task with little interdependence. Organic societies contain a complex intermingling of contrasting consciousness and varying social values while implying that individuals perform varying task with a structured interdependence.

Tönnies (1887) proposed two forms of social interaction, termed of "Gemeinschaft" and "Gesellschaft." Tönnies' concepts are similar to Durkheim's in that the less developed Gemeinschaft communities are composed of people with similar backgrounds who mostly hold similar ethics and morals, while people in Gesellschaft communities contrast one another in beliefs, morals, and ethics. Mechanical and Gemeinschaft communities fit the general

characteristics of smaller rural populations compared to organic Gesellschaft communities, the explanations of which better fit the complexity and interactions of denser urban areas.

The definition of rural areas in examining rural development has been met much ambiguity. For example, regarding the social context of rural communities, Castro (2012) generalizes that the family is the most stable organization in rural communities. This synopsis is accurate for many rural examples, but other modern literature suggests that rural communities contain remarkable heterogeneity and evolving nature, moving away from a generalized homogeneity and disadvantaged reputation (Campbell, Campbell, & Hughes, 2004; Meador, 2019; Diaz-Chavez, 2019).

Based on the definition of rural areas provided by the US Census Bureau, the 2010 Decennial Census reported that almost 60 million people, 19% of the population, lived in rural areas (US Census Bureau, 2019). Table 4.1 depicts the Rural-Urban composition of the US since 1900.

Table 4.1. Composition of the US in terms of Rural and Urban areas beginning in 1900

Year	Urban Area Composition	Rural Area Composition
1900	39.6%	60.4%
1910	45.6%	54.4%
1940	56.5%	43.5%
1950	64.0%	36.0%
1960	69.9%	30.1%
1990	75.2%	24.8%
2000	79.0%	21.0%
2010	80.7%	19.3%

Historically, the reduction of rural populations has been contributed to increased economic opportunities in large cities, resulting in patterns of migration from rural to urban areas for employment opportunities and increased social innovation, otherwise known as urbanization. Xie, Weng, and Fu (2019) found that urbanization is occurring more rapidly in the South

compared to Northern states. As a result, rural communities in the region are losing valuable and necessary tax bases, experiencing overall economic losses much faster than that of urban areas. As people move away and local governments lose tax bases, a snowball effect occurs. Less tax money results in lower expenditures for public infrastructure, which further encourages people to migrate to urban areas.

Recently, there has been increased consideration in understanding how social, environmental, and economic interactions occur in rural-urban interfaces. Rural areas have many distinctions from urban settings, but the idea of a rural-urban interface conceptualizes their dichotomy on a continuum, allowing for an interface to occur more harmoniously (Meador, 2019). Rural-Urban interfaces are the areas in which rural and urban areas meet and intermingle. They are comprised of social, economic, and environmental interdependencies that require proper governance, planning, and cooperation in order to link peoples and communities (Brown & Shucksmith, 2017). However, the same is said for interdependences between extractive companies and rural communities.

4.1.3. Public Perceptions

4.1.3.1. Extractive Industries

Extractive industries can only establish operations in areas with adequate raw materials, as opposed to other manufacturing industries that choose locations based on market conditions and consumers (Levitt, 2016). Throughout an extractive natural resource process, waste, dust, emissions, and other types of pollutants are often generated and can be released into the surrounding environment. Consequentially, extractive industries run the risk of creating negative environmental impacts concurrent to affecting socio-economic, health, and livelihood aspects of local communities. The presence of extractive industries are proportionately higher in rural

towns compared to populated cities, causing more significant impacts on smaller and more dependent communities (Brandeis & Guo, 2016). Local jobs and economic stimulation are often the results of trade-offs with environmental and social impacts. However, the scale of these impacts on the social development and quality of life of a community is influenced by geographic location and local economic conditions (Diaz-Chavez et al., 2019). The changing qualities of rural communities hold important implications for extractive industries.

The research regarding the influence of extractive industries on socio-ecologic and socio-economic systems is nascent but highly relevant to the modern sustainable business culture of CSR. Much attention has been given to community perception research regarding the activities and operations of oil, gas, and mining industries, which unveils recurrent environmental, social, and economic issues. These perceptions and common themes begin to outline a relationship between industry and community, but do not fully identify multijurisdictional relationships; instead, they act as observations of individual communities and opportunities lending to CSR endeavors.

In one example, Stedman et al. (2012) found that New York and Pennsylvania communities in proximity to natural gas extraction sites were concerned with water quality and quantity as well as criminal issues related to labor migrating into communities, although they received economic benefits from this extractive resource sector. Similarly, in a Texas-based study of a rural county, Theodori and Jackson-Smith (2010) concluded that residents of Tarrant County generally distrusted the intrusion of industry and disliked potential environmental and social consequences of the oil and gas industry, but appreciated the local economic benefits.

In some cases, the perceived economic benefits of extractive industries supersede environmental and social issues. Loe and Kelman (2016) identified three main areas of

importance held by residents of a small Norwegian community while exploring local perceptions of the developing Norwegian petroleum industry. Residents expressed that job creation, economic multiplier effects, and making the town an attractive place to live and work were principle to the community. Environmental concerns, although reported, were not of great importance to residents.

4.1.3.2. Biomass Energy

Common environmental, social, and economic themes are also presented in the literature regarding biomass energy perceptions. However, unlike fossil fuel industries, public concerns stem from a general misunderstanding of the renewable energy source and how biomass extraction affects local natural resources. Research indicates a generalized negative opinion toward biomass energy. Hitchner, Schelhas, Hujala, and Brosius (2014) state the public's acceptance of forest-based bioenergy as being "…highly contingent on how people interpret and understand the sustainability of energy produced from biomass" (p.62).

For instance, in a study examining 44 peer-reviewed publications, Radics, Dasmohapatra, and Kelley (2015) concluded that biomass energy was the least preferred RES of the general public; trees and wood were low-ranking among the favored sources for biomass energy. Respondents from the collection of articles expressed a general lack of knowledge and concerns regarding the environmental impacts and sustainability of forest feedstock extraction. Similarly, Plate, Monroe, and Oxarat (2010) found the public perceived wood, next to fossil fuels, to be the least feasible means for addressing rising energy demands. Study respondents either wholly supported or wholly opposed a local wood-fueled energy plant, which led the authors to conclude that the negative perceptions could stem from a general lack of knowledge regarding wood energy. Private investments for renewable energy have also been unfavorable toward

wood energy. Aguilar and Cai (2010) reported solar and wind technologies were the most preferred RES investments among US individuals, whereas grass and wood biomass technologies were the least.

The general lack of knowledge surrounding wood energy is of significant interest to the stakeholders of bioenergy markets, as the correlation between public perceptions and policy formation is well established (Davies, 1999; Burstein, 2003; Boby et al. 2016). The emergence of educational agriculture and bioenergy outreach programs serve as an attempt to mollify the concern by informing the general public about the implications of a natural resource-based bio-economy and inherent sustainability issues (NIFA, 2019). These programs work to build on existing knowledge, overcome misconceptions, and address public concerns.

Regardless of informative programs, issues of community acceptance toward biomass projects remain. An example of this issue is embodied by the concept of the NIMBY (Not-in-my-backyard) syndrome, which refers to the paradox occurring when residents call for more facilities or development, then oppose projects when sited near residents' homes (Johnson & Scicchitano, 2012). Wolsink (2000) claims that the NYMBY phenomenon is motivated by the calculated cost and benefits of individual residents. Herein lies one of the major constraints of public acceptance, the unpredictability of public perceptions based on individual experiences and understandings.

Issues revealed by perception research of extractive industries and biomass energy are similar to issues found in media and public literature concerning the wood pellet industry. However, an important distinction between wood pellets and other extractive industries is the renewable aspect of wood and bioenergy, which the literature shows to be widely misunderstood.

A priori beliefs significantly contribute to the development and rationalization of individual viewpoints regarding both extractive industries and biomass energy developments.

4.2. Community Issues and the Wood Pellet Industry

4.2.1. Three-Strand Model of the Social License to Operate

Gunningham, Kagan, and Thornton (2003) expanded on the idea of the SLO and developed a "three-strand model" to understand the relationship between corporate environmental performance and regulations of wood pulp and paper mills. The authors found that a company's compliance with environmental regulations is used as a basis to judge their compliance with the demands of the public, being that policy is influenced by and maintains the publics' best interest (Gunningham, Kagan, & Thornton, 2003). In Gunningham, Kagan, and Thornton (2004), the authors compared the importance of regulatory compliance with other incentives and mechanisms of social control such as public demands and perceptions using the three-strand model. They found that a company's compliance with environmental regulations cannot be explained purely in terms of the regulatory obligations faced, but better explained in terms of the intermingling of social pressures and economic constraints.

The investigation into social, environmental, and economic factors of the SLO from Gunningham, Kagan, and Thornton's three-strand model exploits community pressures, regulating policy, and financial interaction to provide insight into industry issues and the behavior of companies in closely watched industries. The model is composed of three licenses or the intermingling criteria of public acceptance: the social license, legal license, and economic license (Figure 4.1). For this reason, the three-strand model will be adapted and used to examine the issues in the literature regarding interacting social, environmental, and economic constructs of the pellet industry by examining each license and implications. Furthermore, based on the

work of these authors and ideas aforementioned in this review, the three principle constructs are independent variables and company profile is the dependent variable of this thesis (Figure 4.2).

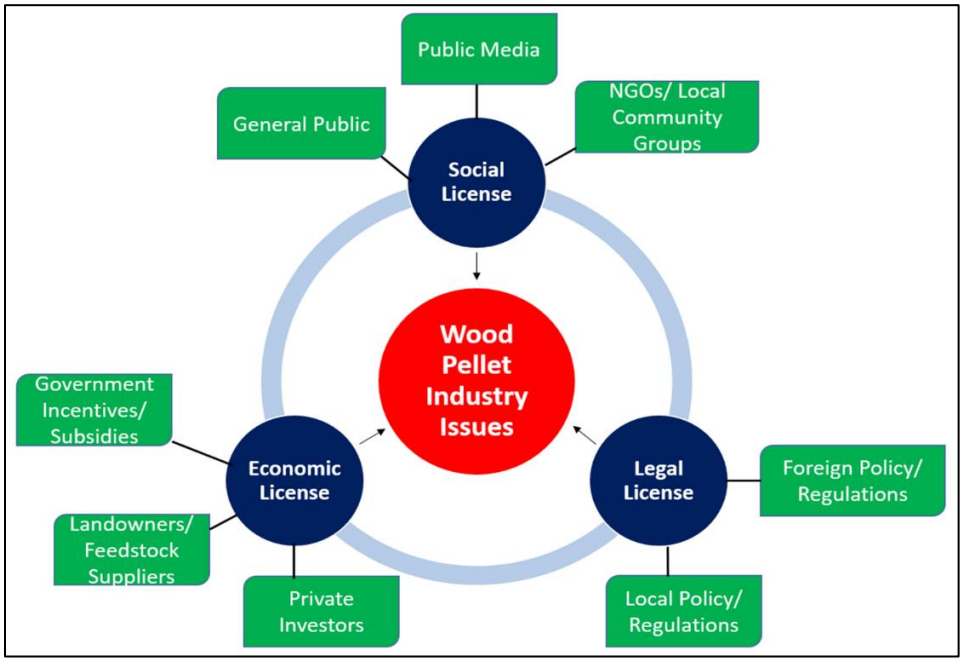

Figure 4.1. The Three-Strand Model of the Social License to Operate, including intermingling stakeholders/ influencers

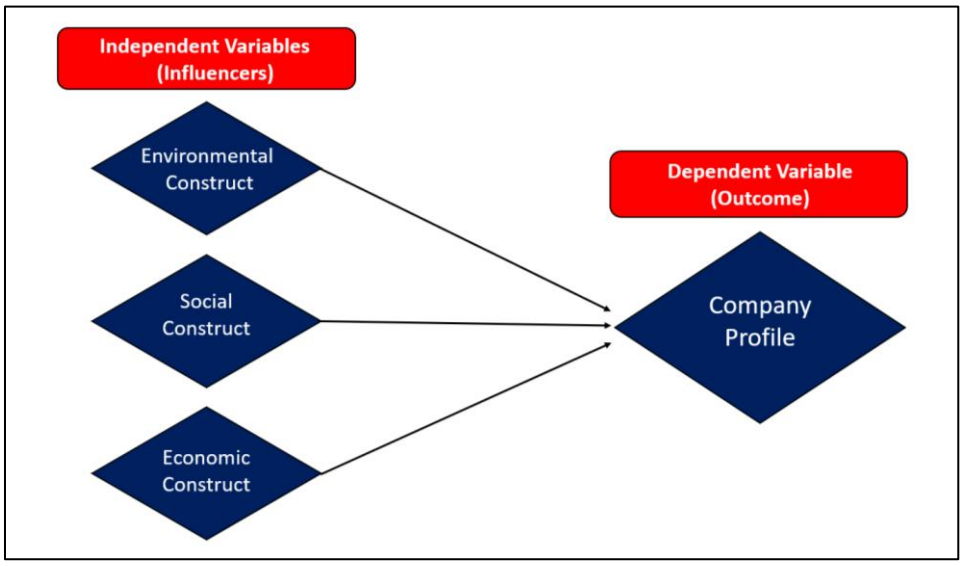

Figure 4.2. Independent and dependent variables included in this thesis

4.2.2. Social Construct

4.2.2.1. Social License

The three-strand model's social license construct consists of the demands from environmental and community groups, who hold power to influence public policy by lobbying local and state governments as part of the political process. The majority of literature expressing issues of industry stems from environmental Non-government organizations (NGO) and special interest groups, which do not represent the general public but express concerns through publications and media outlets that serve to influence the greater public (Hitchner et al., 2014). It is within this license that organized opposition and lawsuits from NGOs and the general public are held against the industry.

4.2.2.2. Social Conflict

Much of the community-level concern towards pellet manufacturing is related to the physical impacts from mills such as increased traffic, noise, air, and water pollution as well as siting issues from production operations (Diaz-Chaves et al., 2019). Transportation throughout the pellet supply chain generates emissions along with increased road and rail traffic, noise pollution, and degradation to municipal roadways. As the industry grows, it will progressively require more transportation and production, increasing social conflict from surrounding communities.

Public opposition of pellet mills has already been observed in various context concerning siting and operations (Anderson, & Powell, 2018; Froelich, 2018; Winser, Musil, Tiwari, Sung, & McAuliff, 2019). An example of social conflict within the pellet industry comes from the Dogwood Alliance, an environmental NGO that has published many anti-pellet industry articles,

including a handbook titled Community Toolkit, which details instructions to build a social movement against the industry (Macon & Quaranda, 2018).

4.2.2.3. Air Quality

Air quality concerns are due to the potential release of harmful volatile organic compounds such as carbon monoxide, CO_2, nitrous oxides, and sulfur oxides during production at manufacturing facilities. These compounds can degrade human health as well as air/water quality when they are released into the environment. Anderson & Powell (2018) examined air quality compliance of Southern pellet mills in a report titled *Dirty Deception: How the Wood Biomass Industry Skirts the Clean Air Act*. The authors reported that in 2017, air pollution from 11 out of 21 mills exporting in the South was either above limits set by the Clean Air Act or not equipped with required emission control devices. The American Lung Association and American Heart Association, along with dozens of other medical interest groups report that decreased air quality has been correlated to many respiratory and cardiovascular-related problems, (Brook et al., 2010; Koester & Davis, 2018).

Recently, Enviva and Drax have reached settlement agreements with the Department of Environmental Quality regarding emission output levels and air permits for some of the companies' facilities. Clean Air Carolina, an air pollution and environmental justice advocacy group, challenged air permits previously granted to Enviva's Hamlet and Sampson pellet mills regarding the state's high allowance of emissions output. Similarly, Drax Morehouse Bioenergy faced challenges from the Environmental Integrity Project and Sierra Club concerning a proposed renewal of the mill's air permit. In all three cases, the mills were required to install upgraded air pollution control structures to remain compliant with public policy.

4.2.2.4. Environmental Justice Communities

As alluded to earlier, the placement of wood product manufacturing facilities is proportionately higher in rural towns compared to more populated cities, causing a more significant effect on small dependent communities. As a result, rural communities experience marginalized effects when it comes to the siting of wood pellet mills. Environmental justice communities are highlighted in the literature as they relate to the siting of extractive industries. Environmental justice communities are defined as communities with high levels of poverty and a large non-white population. The concern from Koester and Davis (2018) was that the wood pellet industry takes advantage of rural areas' low-cost land and place a burden on economically struggling communities with environmentally degrading operations. The authors found that 282 of the 793 counties in nine southern states met the conditions of an environmental justice community. In the study, 18 out of the 32 pellet mills were located within an environmental justice community; concluding that pellet mills, in a systematic pattern, are 50% more likely to be sited in an environmental justice community, which experienced more significant impacts compared to a non-environmental justice community (Koester & Davis, 2018).

4.2.3. Environmental Construct

4.2.3.1. Legal License

The legal license construct of the three-strand model consists of the demands of regulating agencies that create policy and laws to modulate environmental impacts while keeping society's best interests in mind. Although these agencies work to preserve environmental sustainability, policy alone cannot regulate every aspect of public concern. While sustainability criteria are in place from multiple wood pellet certification schemes and global legislation, environmental degradation from feedstock sourcing and carbon accounting of the wood pellet

supply chain are among the most debated environmental issues. Social and environmental constructs are closely related as environmental issues often initiate social conflict.

4.2.3.2. Forest Sustainability Issues

Water, soil, wildlife habitat, and biodiversity can be affected by the wood pellet industry. The research on forest soil and water quality effects from the extraction of logging residues for pellet production, however is relatively new. Studies in this context typically focus on post-harvest residual extraction for pellet production related to forest health and soil organic matter retention required for reforestation. Lindroos et al. (2016) found that the extraction of logging residues in Finland removes a broad availability of soil nutrients retained in forests following timber harvest. Nutrient retention within a forest is an ecosystem service that serves to regulate the nutrient balance in both soil and water. Consequentially, removing nutrients has potential long-term effect to the acidity of waterways and soil (Nykvist, & Rosén, 1985; Kreutzweiser et al., 2008).

Feedstock sourcing faces much criticism from NGOs and community groups, exemplified in publications like the Rachel Carson Council's *Clear Cut: Wood Pellet Production, the Destruction of Forests, and the Case for Environmental Justice* and Dogwood Alliance's *Vanishing Treasures: Threatened Wetland Forest In The Southern US Need To Be A National Conservation Priority*. Although sawmill, logging, and urban residues as well as pre-commercial thinnings account for less than 1% of all US forest products by weight, the clear-cutting of bottomland hardwood forest and loss of forest biodiversity are among the top concerns related to wood pellet feedstock extraction (Dale et al., 2017).

Forest soil and water quality concerns from harvesting practices have long been mitigated in the US. Sustainable harvesting methods include best management practices (BMPs) that were

established after congressional passage of the Federal Clean Water Act of 1972. The effectiveness of BMPs on non-point pollution is proven effective in the preservation of adjacent streams and waterways, which is an integral part of sustainable forest harvesting and management (Xu & Xu, 2018). Sustainability criteria of the RED and RED II are also intended to protect wetlands and areas with high biodiversity because of their ecological services; this includes many bottomland hardwoods.

Overall, feedstock sourcing for the pellet industry in the South has predominantly come from forests comprised of pine species. In 2018, the South contained 43 mills that used a mixed 18% hardwood, 48% softwood, and 33% hard and softwood feedstock on average (BBI International, 2018). Hardwood feedstock is more prevalent in the Atlantic Coast region, while pine feedstock is predominant in the Gulf Coast.

Many Pellet manufacturers defend feedstock sourcing by sharing their sourcing activities to the public in the spirit of transparency and an attempt to convey commitment to CSR. For example, Enviva's Track and Trace Program tracks and records truckloads of procured wood, as well as the condition and location of harvest sites, for pellet production. Also required by many wood pellet manufacturers and importers, voluntary third-party certification schemes are intended to ensure quality and sustainable feedstock sourcing. These schemes, which include forest management and chain-of-custody programs from the forest to the end customer, include the Sustainable Forestry Initiative (SFI), Sustainable Biomass Program (SBP), Forest Stewardship Council (FSC), Programme of the Endorsement of Forest Certification (PEFC), and EnPlus Certification (specific to wood pellets). In addition to Enviva's Track and Trace program and certification schemes, research scientists audit biomass sources, account for emissions

during production, determine supply chain energy expenditures, measure mitigation of pellet companies, and conduct life-cycle analyses of the pellet industry.

4.2.3.3. Wood Pellet Life-Cycle and Carbon Neutrality

The IPCC, EU RED I and II, UN Kyoto Protocol, and the US EPA have all deemed that burning woody biomass is carbon neutral, meaning that utilization does not lead to additional GHG emissions over the wood-of-origin life-cycle. In theory, a carbon sink forms between the carbon produced from pellet production and final combustion, which is sequestered and offset by the regeneration of trees through natural or seedling afforestation.

However, discrepancies regarding the carbon neutrality of wood pellets have divided public, government, and academic opinion, raising more questions about the sustainability of wood pellet energy. National accountability measurements vary, and as a result, energy expenditures and emissions output calculations are diverse in life-cycle literature.

The life-cycle of Southern wood pellets can be basically divided into five phases: feedstock collection, pellet manufacturing, shipment to import port, transportation to consumer, and combustion for energy generation. Energy expenditures and emissions produced during the life-cycle, from US forests to foreign power stations, are unclear, as they vary by raw material, transport distances, transport fuel requirements, mill electrical requirements, and efficiency of power stations.

Given these caveats, starting from timber harvesting, total estimated emissions of the industrial pellet life-cycle amounts to 236 kg CO_2/ Mt of pellets but can vary between 113kg CO_2/ Mt and kg 482 CO_2/ Mt of pellets (Magelli et al., 2009). Some studies do agree that pellet production followed by transatlantic shipment are the most energy-intensive phases of the cycle; one study notes these steps account for around 40% of total energy (Magelli et al., 2009).

However, the proportion of life-cycle emissions for all phases are debated. The UK Department of Energy and Climate Change reports that US production and export account for 25% of total life-cycle emissions. Dwivedi, Johnson, Greene, and Baker (2016) found that feedstock collection ranged from 6% to 35% of total emissions while manufacturing accounted for 45% of total emissions; most notably from drying during the manufacturing process. The authors found transatlantic shipping and combustion to account for 28% and 10%, respectively. Conversely, another study found transport emissions to exceeded manufacturing emissions (Röder, Whittaker, & Thornley, 2015).

Some studies suggest that the carbon output of exported wood pellets for energy generation is higher than that of coal-based energy, but the majority of the literature suggest carbon-neutrality or a significant reduction in carbon emissions. For instance, the Rachel Caron Council recognizes the flawed carbon accounting of wood pellets and exerts that burning wood pellets releases 65% more CO_2 than coal per MWh. However, potential carbon reductions presented in scientific literature indicate savings of 62% to 94% (Dwivedi, Khanna, Bailis, & Ghilardi, 2014; Röder et al., 2015; Wang, Dwivedi, Abt, & Khanna, 2015; Dwivedi et al., 2016; Morrison, Daystar, & Golden, 2018).

Variations in energy expenditures, emissions output, and carbon accounting add to the misunderstanding of the emerging renewable fuel, which was also indicated by perception studies of general biomass energy. As national policy looks to science to guide the process, accurate assessments are critical for addressing bioenergy use concerns that actively drive debates over wood pellets.

4.2.4. Economic Construct

4.2.4.1. Economic License

The economic license construct of the three-strand model consists of the demands of lenders, investors, and those who hold an economic interest in the profitability of a business, including private and government entities. In the wood pellet industry, state economic development agencies, private investors, and federal governments fall into this license. Mentioned earlier, tax incentives from state economic development agencies provide strong support to wood pellet manufacturing companies. For example, Louisiana's two wood pellet mills are owned by Drax Biomass, who began development negotiations with the state in 2012. Drax received a custom incentive package, including a $1.7 million Economic Development Loan Program commitment that will not require repayment unless the company fails to meet payroll performance obligations (LED, 2019b). Similarly, in 2013 Louisiana Pellets Inc. received approval for an industrial tax exemption worth $75 million for a $239 million pellet mill project in La Salle Parish, which was bought by Drax in 2017 (LED, 2013; Drax, 2019). Under the Louisiana Quality Jobs Program, Drax received approval in 2014 for $1.3 million in payroll rebates over ten years for a $100 million investment in the Morehouse Bioenergy pellet mill (LBCI, 2014).

4.2.4.2. Economic Interaction

In the context of a social entity, pellet mills acquire intangible resources, human, social, and financial capital while attempting to operate in a symbiotic manner with government and society (Meyskens, Carsrud, &Cardozo, 2010). Employees represent human capital, a relationship with local communities represent social capital, and the acquisition of investments represents financial capital. To this end, community relations regarding an available local labor

force and the willingness of surrounding landowners or other mills to supply raw materials are vital aspects for the continued existence of the industry (Henderson, Joshi, Parajuli, & Hubbard, 2017).

The association between emphasizing economic interest at the perceived expense of ecosystem services is a trade-off of that stirs emotions amongst many groups of stakeholders. Franks et al. (2014) examined the effects of social conflict in extractive industries as a cost to businesses and in effect, society. Organized opposition and lawsuits can lead to the delay and sometimes abandonment of projects, which results in the further depletion of a business-community relationship and prevents a company from upholding its obligations to investors and stakeholders.

Henderson et al. (2017) conveyed the economic benefits to local communities from mill construction to operation, and is a useful example of negotiating support such as state incentives and subsidies. However, in terms of jobs, Diaz-Chavez et al. (2019) suggest that the pellet industry is becoming more automated and therefore, can only offer relatively minimal numbers of direct jobs to local communities. They suggest that the majority of economic stimulation results from multiplier effects felt throughout the community, primarily in the wood products and transportation industries, which are crucial to the supply chain of the pellet industry.

As part of the economic multiplier effect, landowners directly and indirectly employ forest managers, loggers, and truck drivers, but are not publicly supported to manage timberlands, which provide valuable services to local communities.

Counter to environmental degradation issue positions, Anderson and Mitchell (2016) found that the removal of dead trees and logging residues (including for pellet production) reduces wildfire fuels and present an opportunity to salvage otherwise unusable forests affected

by insects or drought. Reduction of wildfire threats protects local communities from costly natural disasters, while further stimulating and maintaining local forest economies. Diaz-Chavez et al. (2019) argue that income from the pellet industry can assist landowners in maintaining productive and ecologically valuable forests.

4.2.4.3. Foreign Subsidies and Incentives

Outside of the US, economic issues involving subsidies and incentives result directly from policy establishment. The variations and uncertainties of carbon accountability during the wood pellet life-cycle concern not only the public but policymakers and those who provide fiscal incentives to the demand side of the industry.

Standing alone economically as an energy source, wood pellets are not a lower cost alternative to fossil fuels; financial incentives and subsidies on the demand side (and supply side) currently keep the industry afloat. In the UK, the average unit production cost of electricity from imported wood pellets is 30% higher than that of fossil fuels without support mechanisms (Dwivedi, Johnson, Greene, & Baker, 2016). Conversely, the cost is 16% lower than coal with support mechanisms in place. Recently, the UK announced new criteria for the CfD subsidy. The new requirement for carbon emissions produced during the life cycle of imported wood pellets must be 29 kg CO_2/megawatt-hour to be eligible for the CfD scheme regarding plants commissioned after 2021. Previous criteria for the scheme was 200 kg CO_2/ MWh. In 2017, Drax reported its average wood pellet emissions to be 129 kg CO_2/ MWh. While this is not the first indication of stricter regulations for government support, it has stark consequences for potential new power stations.

To battle new criteria and further reduce environmental degradation, Drax has announced a carbon reduction initiative in which the company plans to develop technology that will capture

and store CO_2 emissions produced by the company's Shelby power station. The technology would be the first of its kind and would potentially enable Drax to deliver negative net emissions from wood pellet combustion.

CHAPTER 5. METHODOLOGY

5.1. Study Region and Research Population

The study region was composed of two main US South sub-regions where pellet production is concentrated; the Gulf Coast, including Louisiana and Mississippi, which utilizes softwood pine as primary feedstock and the South Atlantic Coast, including North Carolina, South Carolina and Virginia, which utilizes hardwood as primary feedstock. The two sub-regions were further segmented into the following areas of interest:

1. 50-mile radii around selected wood pellet mills

2. The two largest metropolitan statistical areas (MSA) in each of the states where selected mills were located

This segmentation yielded three radii and five MSAs per sub-region, which totaled six wood pellet mills and 10 MSAs (Figure 5.1 & Tables 5.1 & 5.2).

An email list comprised of 7,500 residents, including demographic data, was purchased from the direct marketing services company, Exact Data. The list was randomly but proportionately selected by ZIP code and limited to residents 18 years or older that owned or rented homes within the collected ZIP code lists.

List parameters, spanning 171 counties and 1,139 ZIP codes for inclusion in the sample frame were: 1) Counties with a land mass of 50% or more contained within the 50-mile radii from selected pellet mills; 2) Counties within MSAs defined by the US Office of Management and Budget and; 3) Residents older than 18 years of age. As shown in Figure 5.1, the radii around mills 1 and 2 overlapped, as well as the radii around mills 2 and 3, causing duplicates amongst individual ZIP code lists. To resolve this issue, duplicates were kept in the list for mill 1 and deleted from the mill 2 list. The same procedure was followed for mills 2 and 3. Mill 2

maintained the duplicate codes, which were removed from mill 3. Duplicate ZIP codes also occurred between mill 3 and Baton Rouge and Memphis MSAs, mill 4 and Virginia Beach-Norfolk- Newport News MSA, mill 5 and Raleigh- Cary MSA, and mill 6 and Greenville-Mauldin- Easley and Columbia MSAs. To resolve this, every other duplicate was deleted from one list and maintained by the other. In the case that a mill's ZIP code list coincided with two MSAs, the procedure was repeated for the second MSA once the first was completed. In addition, ZIP codes with a population of zero were removed.

As mentioned earlier in this section, mills in the Gulf Coast and Atlantic Coast vary by types of feedstock utilized for pellet production. The 50-mile radius around mills was chosen to gather data from residents who potentially experience direct impacts from the industry, supply forest feedstock to mills, or live in rural communities. MSAs were elected to act as an urban comparison, contrasting the potentially more intimate mill radii. The quasi control sample base of this study allowed us to draw comparisons between residential perceptions by proximity to pellet manufacturers, softwood-hardwood feedstock, rural-urban settings, and Gulf Coast-Atlantic Coast. These comparisons used demographic, knowledge, and perception data. The implications of this study can be used by policy makers in the formation of public policy and industry to evaluate future potential effects in the regions.

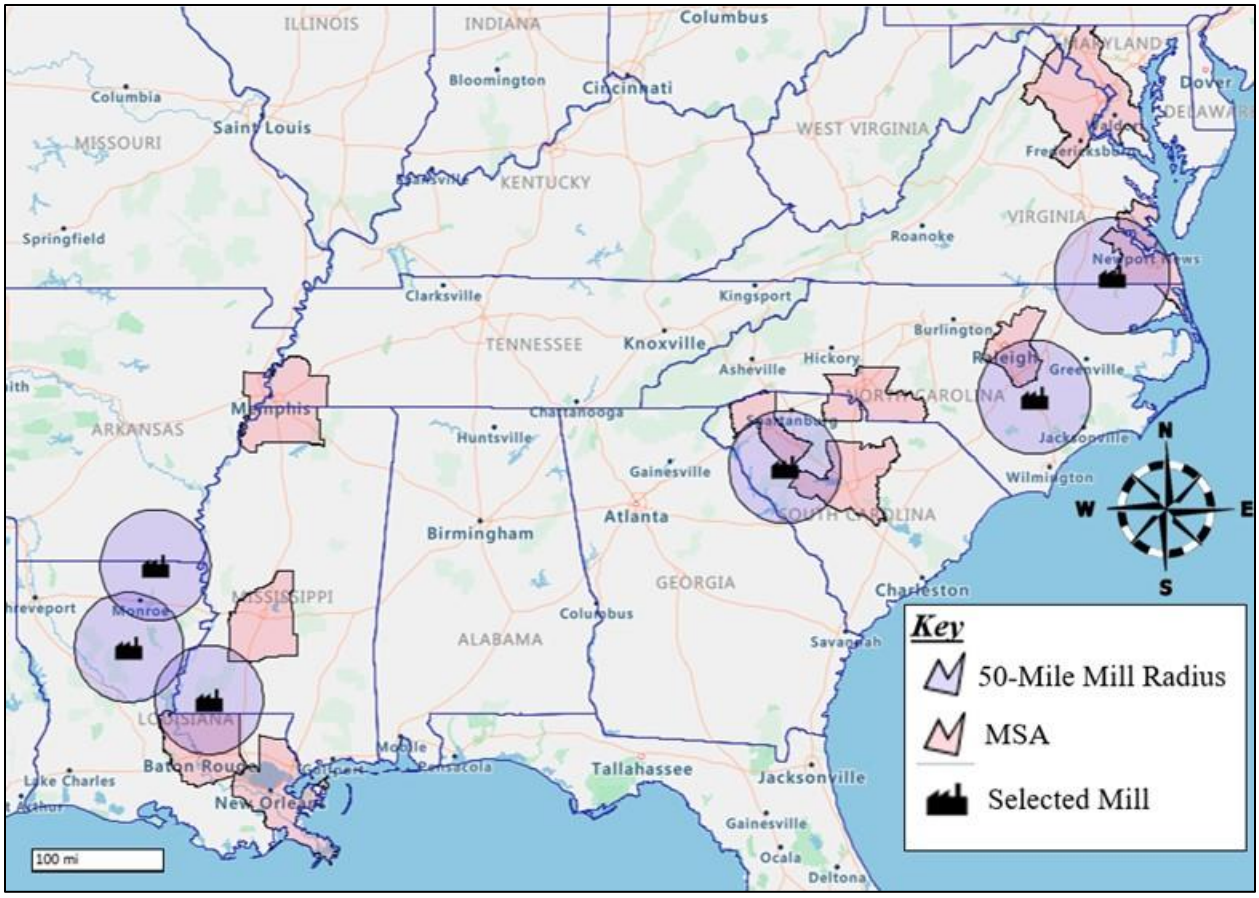

Figure 5.1. Study areas including six selected wood pellet mills and 10 metropolitan statistical areas (created using eSpatial)

Table 5.1. Characteristics of selected wood pellet mills included in the study (SW= Softwood, HW= Hardwood)

Mill	Morehouse	Lasalle	Amite	Southampton	Sampson	Greenwood
Mill Study Number	1	2	3	4	5	6
Sub-region	Gulf-Coast	Gulf-Coast	Gulf-Coast	Atlantic-Coast	Atlantic-Coast	Atlantic-Coast
Company	Drax Biomass	Drax Biomass	Drax Biomass	Enviva LP	Enviva LP	Enviva LP
State	LA	LA	MS	VA	NC	SC

(table cont'd)

City/ Town	Bastrop	Urania	Gloster	Franklin	Faison	Greenwood
Acquisition or Commission	2015	2017	2015	2013	2016	2018
Direct Employees	>60	>70	>60	70	90	80
2019 Capacity (Metric Tons)	525,000	525,000	525,000	550,000	500,000	600,000
Feedstock	SW	SW	SW	HW/SW	HW/SW	HW/SW
Transport from Mill to Port	Train	Train/ Truck	Truck	Truck	Truck	Truck
Exporting Facility Location	Baton Rouge	Baton Rouge	Baton Rouge	Chesapeake	Wilming-ton	Wilming-ton

Table 5.2. Metropolitan statistical areas included in the study

State	MSA 1	MSA 2
LA	New Orleans-Metairie	Baton Rouge
MS	Memphis	Jackson
NC	Charlotte-Gastonia-Rockhill	Raleigh-Cary
SC	Greenville-Mauldin-Easley	Columbia
VA	Washington-Arlington-Alexandria	Virginia Beach-Norfolk-Newport News

5.2. Survey Instrument Design and Implementation

Environmental, social, and economic constructs were included in four sections within a web-based questionnaire. Each of the four sections contained questions regarding perceived impacts relevant to issues of the industry such as pollution, effects to municipal infrastructure, and employment opportunities. An awareness section was included to measure the general

awareness and knowledge of residents concerning the wood pellet manufacturing industry. The final section was comprised of socio-demographic inquiries to compare sample data to the population data gathered from data provided by the list company, ExactData.

The survey instrument contained fixed response, open-ended, and scale questions to measure the environmental, social, and economic constructs, which were independent variables influencing the dependent variable, company profiles. Scale questions were adapted from Likert-type scale found in Bruner, James, and Hensel's (2001) *Marketing Scales Handbook,* volume III, and Bearden, Netemeyer, and Haws' (2011) *Handbook of Marketing Scal*es, 3rd edition. Open-ended questions were designed to give respondents the opportunity to present answers that were not included in the survey instrument.

Procedures, follow up efforts, and data analysis were implemented using a modified version of the Tailored Design Method (Dillman, Smyth, & Christian, 2014). The survey instrument was developed and administered using Survey-Monkey®. The initial mailing was sent to 7,500 recipient emails. A second mailing was sent 10 days after the initial mailing to non-respondents and partial respondents to remind them to complete the questionnaire. *At the time of the second mailing, Hurricane Dorian was threatening the Gulf and Atlantic Coasts, which may have impacted the ability of potential respondents in its path to complete the questionnaire, affecting the response rate of the survey.*

5.3. Data Handling and Analysis

The survey variables were exported from Survey-Monkey® into a database in Microsoft Excel to ease the process of further analysis. The Excel database stored records of returned responses from each mailing, demographic variables from the list provider ExactData, and data obtained by the survey instrument. Statistical analysis of the data was performed using SPSS

version 25; a statistical program widely used in social science research. Descriptive statistics including frequencies and mean responses, independent sample two-tailed t-tests, χ^2 test, and Analysis of Variance (ANOVA) tests were utilized for the analysis.

CHAPTER 6. RESULTS

6.1. Response Rate and Respondent Demographics

Of the 7,500 surveys administered, 1,112 were either undeliverable or inappropriate due to respondents' previous unwillingness to participate in Survey-Monkey® based surveys, or their unwillingness to participate in this survey. The total number of useable surveys received was 122, for an overall adjusted response rate of 2%. Adjusted response rate was calculated using the following formula:

Adjusted Response Rate = Useable Surveys / [Total Sample – (Undeliverables + Unusables)] %

Nonresponse bias was measured using an independent sample two-tailed t-test conducted on age, zip code, and income, comparing respondents and non-respondents that did not fall into the undeliverable or unusable categories. No statistically significant difference was detected at $\alpha = 0.05$ significance level. In addition, research has shown that late respondents typically respond similarly to non-respondents (Armstrong & Overton, 1977). Accordingly, respondents to the second mailing were used as a proxy for non-respondents and compared to first mailing respondents using 84 continuous variables. Less than 5% of all continuous variables comparing first and second mailing respondents were found to be statistically significantly different at $\alpha = 0.05$ significance level, therefore, nonresponse bias was not a problem. Those four variables were contained within three banks of questions; two in an adaptation of the New Environmental Paradigm scale (Dunlap, Liere, Mertig, & Jones, 2000), one in a question concerning energy priority, and the last in a bank of statements concerning environmental perceptions of the wood pellet manufacturing industry. The variables were "Humans will eventually learn enough about global warming to be able to control it", "If things continue on their present course, we will soon

experience a major climate change catastrophe", "woody biomass", and "Harvesting trees to manufacture wood pellets is harmful to the environment."

Approximately 53.8% (n=65) of respondents were female. Annual 2018 household income was more than $100,000 for 52.3% (n=63) of respondents, and 58.5% (n=65) were 55 or older. In terms of ethnicity, 84.4% (n=64) of respondents were white or Caucasian and 66.2% (n=65) have a college (B.S. or B.A.) or advanced degree (M.S., Ph.D., MBA, JD). As for political affiliation, 38.5% identified as Republican while 33.8% identified as Democrat and 16.9% identified as independent (n=65).

The density of responses received is geographically represented by Figure 6.1, which was based on respondent ZIP codes.

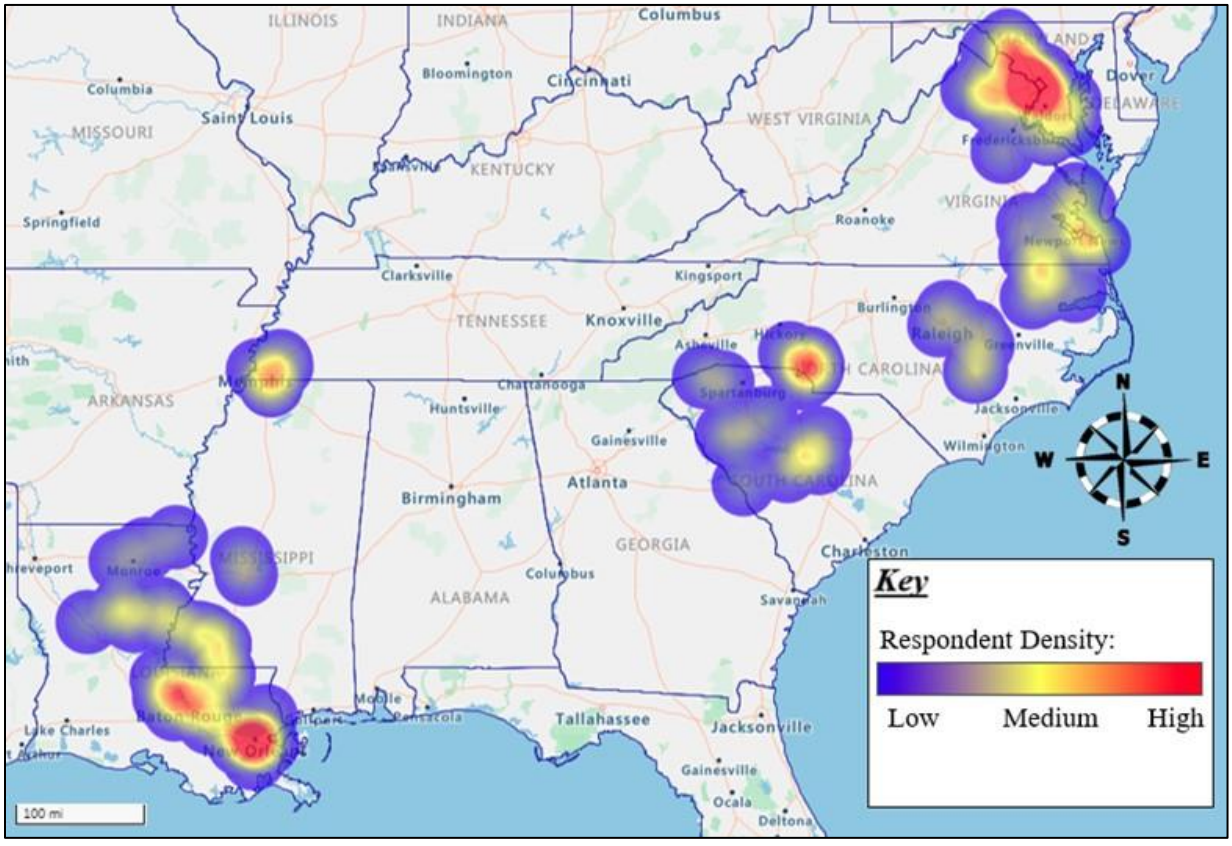

Figure 6.1. Geographic distribution and density of responses (n=122)

6.2. Urban and Rural Comparison

6.2.1. Introduction

As mentioned in the methodology chapter, residents within MSAs were considered to be urban and residents within 50-mile radii of mills were considered rural. As a result of some 50-mile radii overlapping MSAs and the procedure used to remove duplicate ZIP codes in these areas, there was a 7% (9/122) overlap for respondents within 50-Mile radii that were considered urban; these urban respondents were mostly near the outskirts of 50-mile radii (Figure 6.2). Of the 122 respondents, 72.1% were urban and 27.9% were rural.

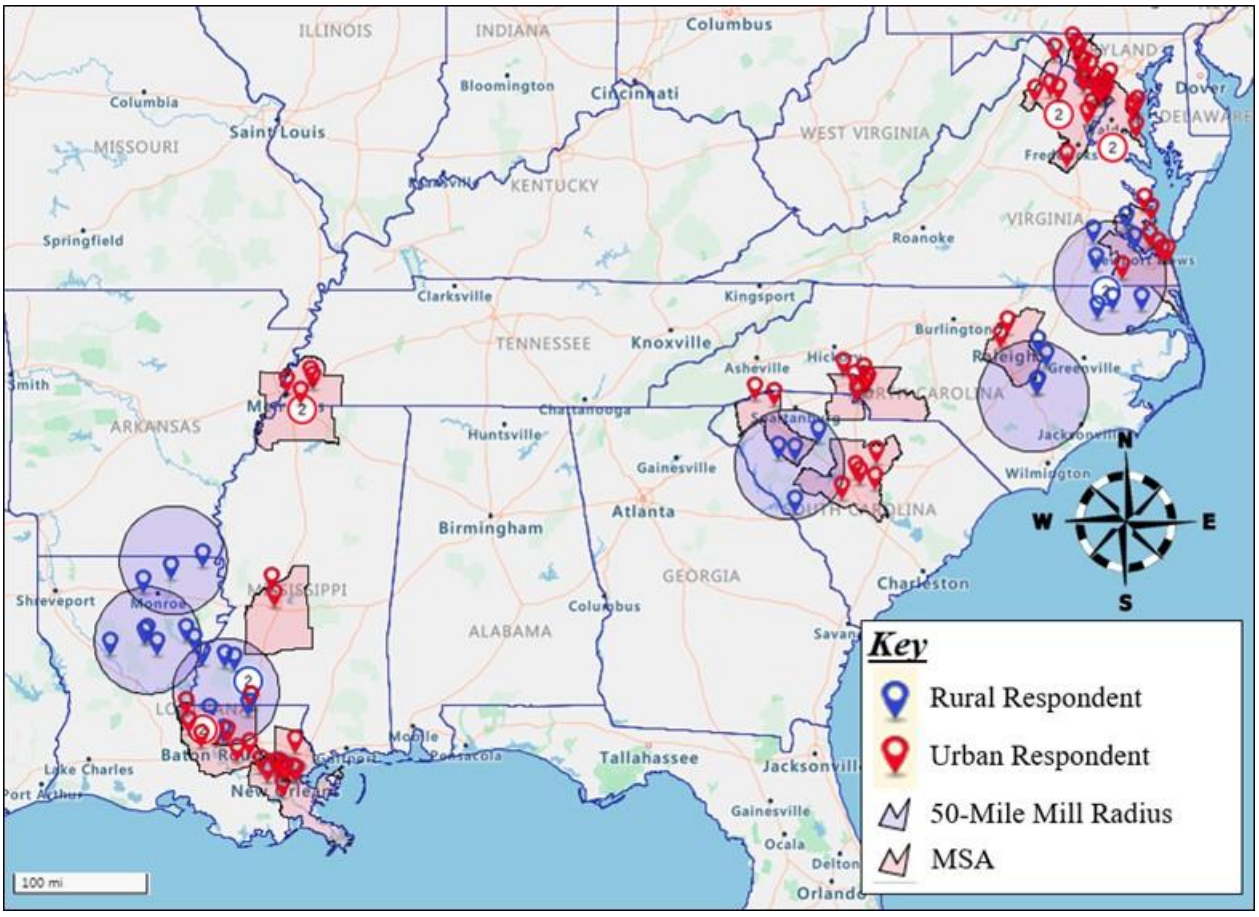

Figure 6.2. Map of urban and rural respondents (n=122)

6.2.2. Wood Pellet Manufacturing Industry Awareness

Using an independent sample two-tailed t-test, rural respondents reported a statistically significant higher awareness of the wood pellet manufacturing industry compared to urban respondents (p=0.007 at $\alpha = 0.05$) (Figure 6.3). The mean response to this question was 2.2 for urban respondents and 3.0 for rural respondent on a five-point Likert-type scale (1=Not at all aware; 2= Not very aware; 3= Neither aware nor unaware; 4= Somewhat aware; 5= Very aware). Also, when asked if they were aware of any pellet manufacturers, 51.9% of rural respondents reported they were compared to 21.7% of urban respondents.

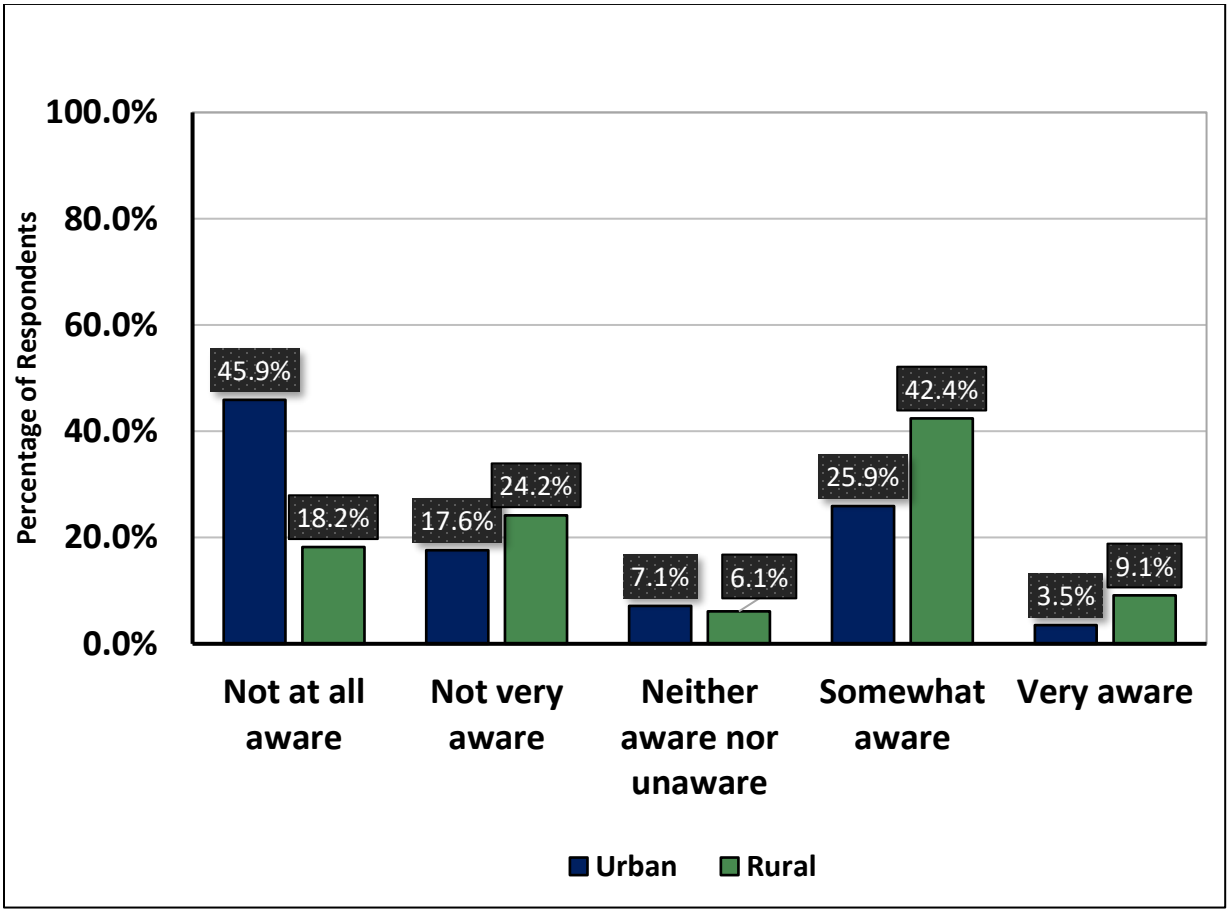

Figure 6.3. Awareness of the wood pellet manufacturing industry (n=118) (1=Not at all aware; 2= Not very aware; 3= Neither aware nor unaware; 4= Somewhat aware; 5= Very aware)

Independent sample two-tailed t-tests were employed to examine whether the awareness and knowledge of pellet manufacturers and industry differed between rural and urban respondents (Table 6.1). The difference in means of both items were statistically significant between urban and rural respondents at $\alpha = 0.01$ significance level, indicating rural respondents were more aware of manufacturers in their states and knowledgeable about the industry because of their higher mean answers. However, the means of the second item were both below the neutral point of three which indicated that neither group claimed to be very knowledgeable about the industry.

Table 6.1. Awareness and knowledge of the wood pellet manufacturing industry (n=68) (1=Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

Item	Urban $\bar{x}$	Rural $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
I am aware of wood pellet manufacturers in my state.	2.0	3.3	*p*=0.000**
I am very knowledgeable about the wood pellet manufacturing industry.	1.8	2.5	*p*=0.008**

Figures 6.4 and 6.5 present what urban and rural respondents think wood pellets are made from and what they are used for, respectively. Both figures are ranked in descending order based on urban responses.

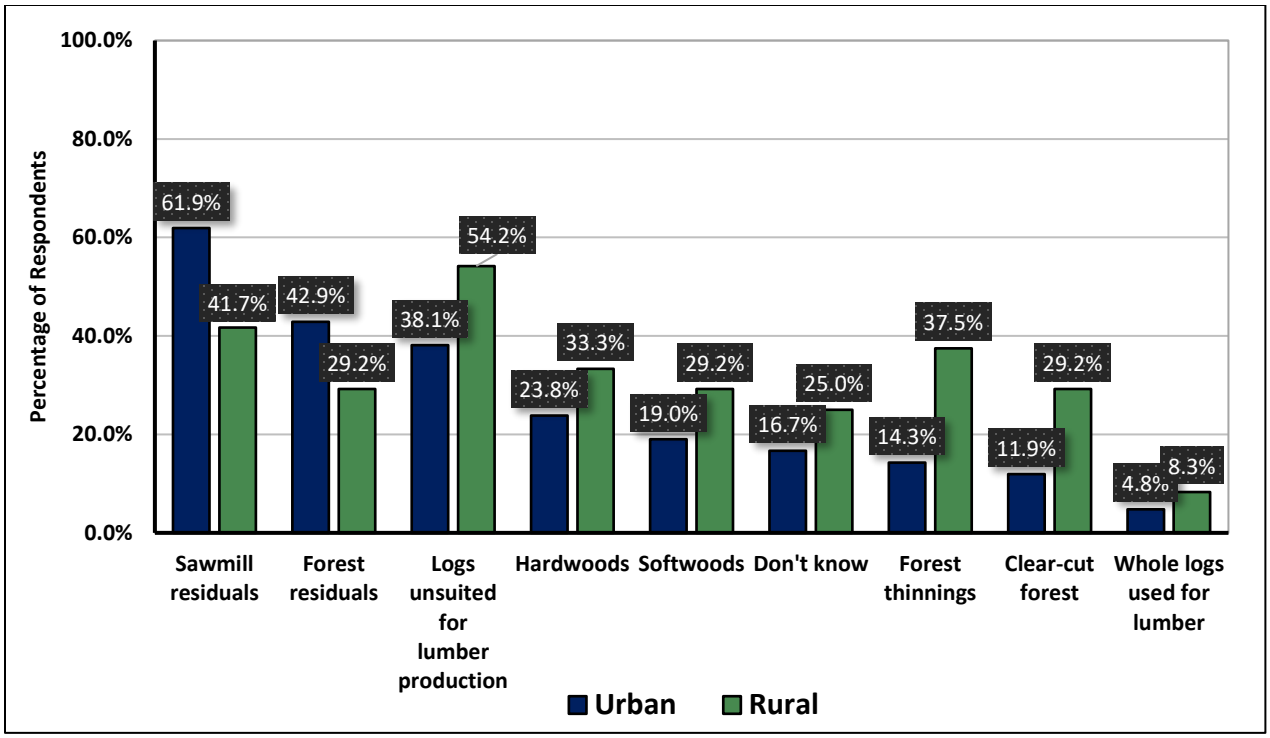

Figure 6.4. What urban and rural respondents think wood pellets are made from (n=66) (Multiple responses possible)

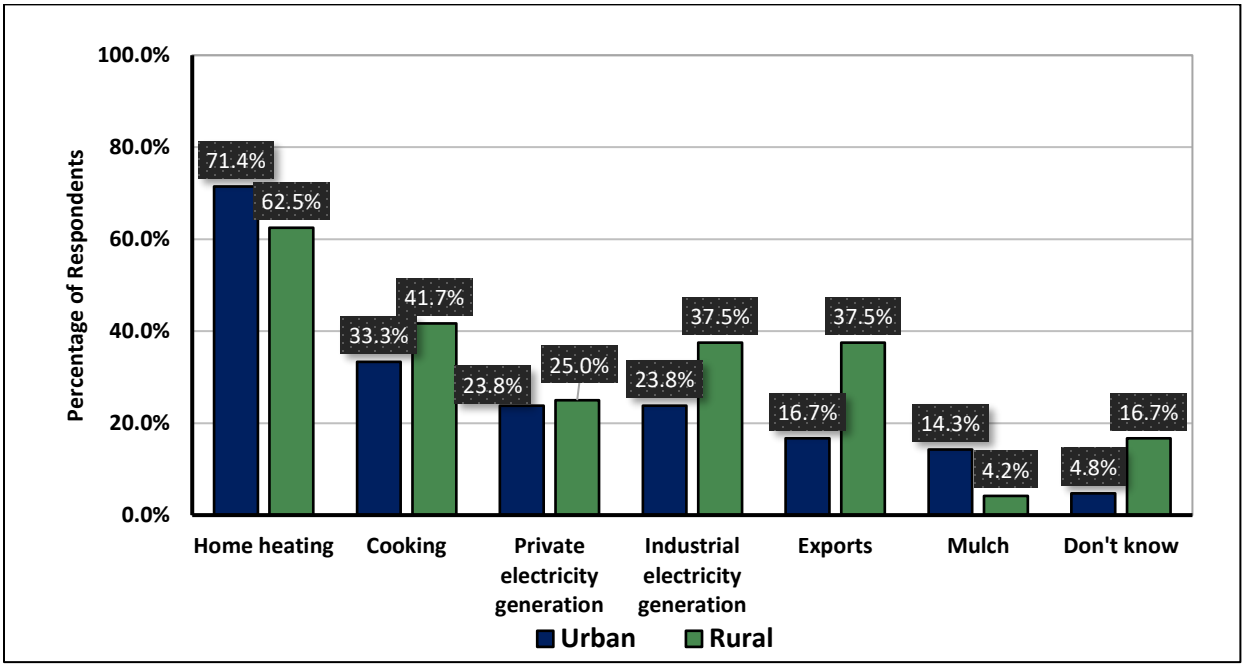

Figure 6.5. What urban and rural respondents think wood pellets are used for (n=66) (Multiple responses possible)

6.2.3. General Environmental, Social, and Economic Perceptions

Respondents were asked to rank their level of agreement for three banks of statements to reveal general environmental, social, and economic perceptions on five-point Likert-type scales (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree). Tables 6.2, 6.3, and 6.4 summarize the results by providing mean responses between urban and rural respondents as well as P-values from independent sample two-tailed t-tests between means.

An adapted version of the New Environmental Paradigm scale (Dunlap et al., 2000) was used to gauge the environmental affinity of respondents and is presented by Table 6.2. Five items were statistically significantly different between urban and rural respondents at $\alpha = 0.05$ significance level, including two that were significantly different at $\alpha = 0.01$. For these five items, urban respondents reported a statistically significantly higher environmental affinity. Urban respondents more strongly disagreed that "the balance of nature is strong enough to cope with the impacts of industrialization", "climate change caused by humans has been greatly exaggerated", "humans were meant to rule over the rest of nature", and "climate change is a naturally occurring phenomena, not caused by humans." Urban respondents more strongly agreed that "humans are accelerating the rate of global warming." Even though the difference of five items were not statistically significant, the means showed that overall, people that live in urban areas have a greater affinity for the environment and were generally more concerned with humans producing negative impacts on the environment.

Table 6.2. Environmental affinity of respondents (n=98) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Urban $\bar{x}$	Rural $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
Humans have the right to modify the environment to suit their needs.	2.6	2.7	*p*=0.692
Human economic needs are more important than protecting the environment.	2.0	2.2	*p*=0.338
When humans interfere with the environment it often produces disastrous consequences.	3.9	3.7	*p*=0.446
The balance of nature is strong enough to cope with the impacts of industrialization.	2.0	2.6	*p*=0.015*
Humans are accelerating the rate of global warming.	3.8	2.9	*p*=0.003**
Climate change caused by humans has been greatly exaggerated.	2.7	3.5	*p*=0.016*
Humans were meant to rule over the rest of nature.	2.2	3.0	*p*=0.008**
Humans will eventually learn enough about global warming to be able to control it.	2.7	2.6	*p*=0.48
If things continue on their present course, we will soon experience a major climate change catastrophe.	3.4	2.9	*p*=0.074
Climate change is a naturally occurring phenomena, not caused by humans.	2.5	3.3	*p*=0.011*

Five statements related to social/ community issues were used to evaluate the social aspect of respondents as they relate to natural resources, recycling, and the environment within their community (Table 6.3). Both groups were generally concerned about the environmental impacts of companies and natural resources within their community and were generally willing to be inconvenienced in order to positively affect their community. Two items were statistically significantly different between urban and rural respondents at α = 0.05 significance level,

including one that was significantly different at α = 0.01. Urban respondents more strongly agreed that themselves or their family recycle and that their community offers a recycling program. However, as stated in the literature review, rural areas generally have insufficient public infrastructure compared to urban areas. Therefore, the difference in recycling practices and programs was to be expected.

Table 6.3. General social perceptions of respondents (n=93) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Urban $\bar{x}$	Rural $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
It is important to me that the companies in my community do not harm the environment.	4.3	4.1	*p*=0.316
I/my family recycles materials such as glass, plastic, and paper.	4.1	3.2	*p*=0.002**
My community has a recycling program in place for materials such as glass, plastic, and paper.	3.9	3.1	*p*=0.012*
I am generally concerned about the natural resources in my community such as forest, air, and water.	4.3	4.3	*p*=0.972
I am willing to be inconvenienced in order to participate in recycling that is environmentally friendly in my community.	4.0	3.8	*p*=0.450

General economic perceptions were evaluated using seven statements related to local economic conditions and government support. Although the difference was not statistically significant, respondents from urban areas agreed more that governments should provide financial support to develop local businesses compared to rural respondents, who agreed more that industry should stand on its own. Only one item was statistically significantly different between the groups at α = 0.01 significance level. Urban respondents more strongly agreed that their

community has a strong economy. Once again, this was to be expected since rural areas are generally associated with marginalization.

Table 6.4. General economic perceptions of respondents (n=91) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Urban $\bar{x}$	Rural $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
Job creation is important to my community.	4.3	4.5	*p*=0.304
My community has a strong economy.	3.8	2.9	*p*=0.001**
A strong economy is important to my community.	4.5	4.4	*p*=0.638
Local government should provide financial support to develop/ maintain businesses in my community.	3.3	3.0	*p*=0.364
State government should provide financial support to develop/ maintain businesses in my community.	3.3	3.1	*p*=0.618
The Federal Government should provide financial support to develop/ maintain businesses in my community.	3.2	2.9	*p*=0.410
Industry should stand on its own without government support/ intervention.	3.3	3.4	*p*=0.623

Respondents were asked to provide their level of agreement on a five-point Likert-type scale regarding the need for different sources of energy to be a priority in the US. According to independent sample two-tailed t-tests, no statistically significant difference was found between urban and rural respondents at $\alpha = 0.05$ significance level. The means of both groups ranked solar followed by hydro energy to be the highest priorities, while woody biomass ranked third to last, and coal the least prioritized (Figure 6.6).

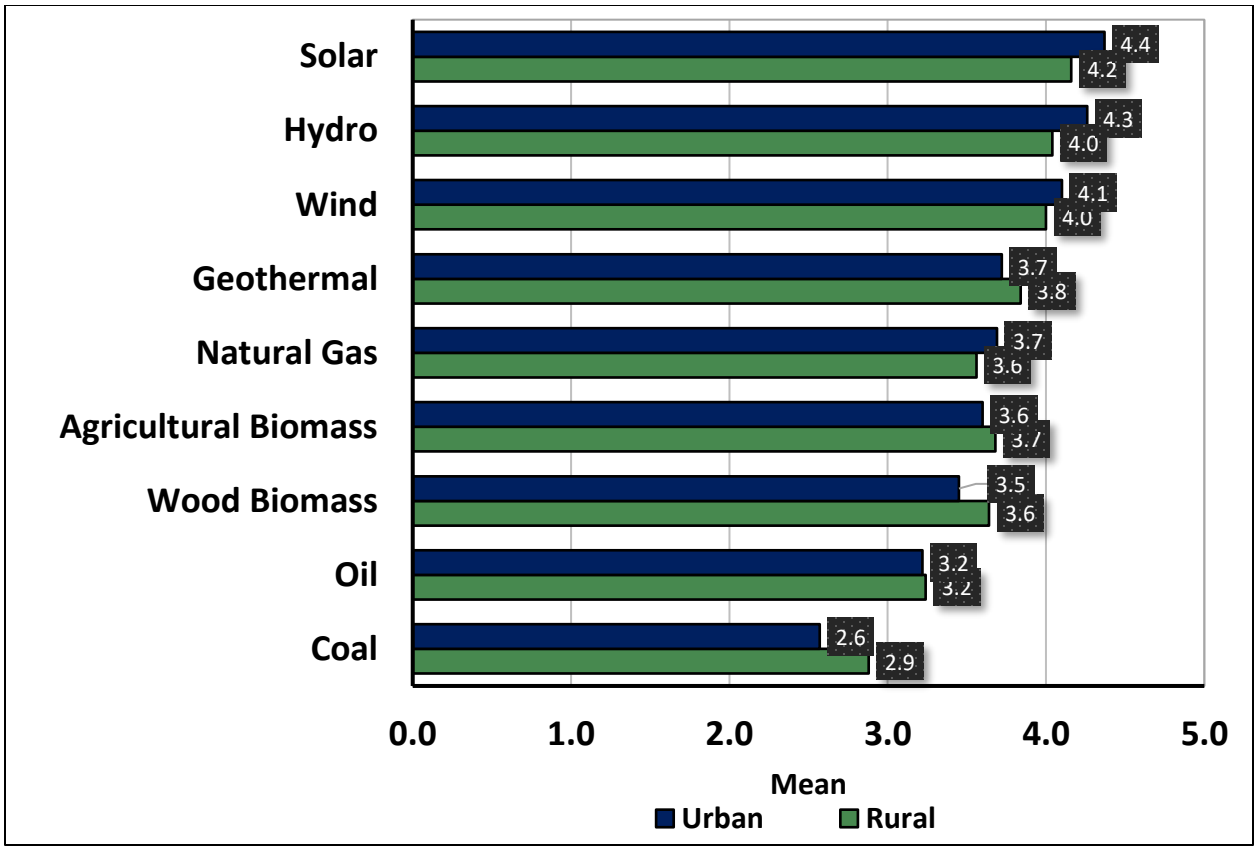

Figure 6.6. Different sources of United States energy ranked by respondent priority (n=84) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

Respondents were also asked for their level of agreement regarding wood pellets as a viable energy alternative to fossil fuels. Although no statistically significant difference was found at $\alpha = 0.05$ significance level, the means were 3.1 for urban respondents and 3.5 for rural respondents on a five-point Likert-type scale (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree), indicating that people living in rural areas thought wood pellets to be more viable compared to urban areas. Similarly, the overall opinion of using wood pellets for energy was more positive from rural respondents than that of urban respondents, although the difference was not statistically significant at $\alpha = 0.05$ significance level (Figure 6.7). Utilizing a five-point Likert-type scale, means of 3.3 and 3.6 were determined for urban and rural respondents, respectively. Both groups had a generally positive opinion of using

wood pellets for energy with 46.3% of urban and 52.2% of rural respondents reporting either somewhat positive or extremely positive.

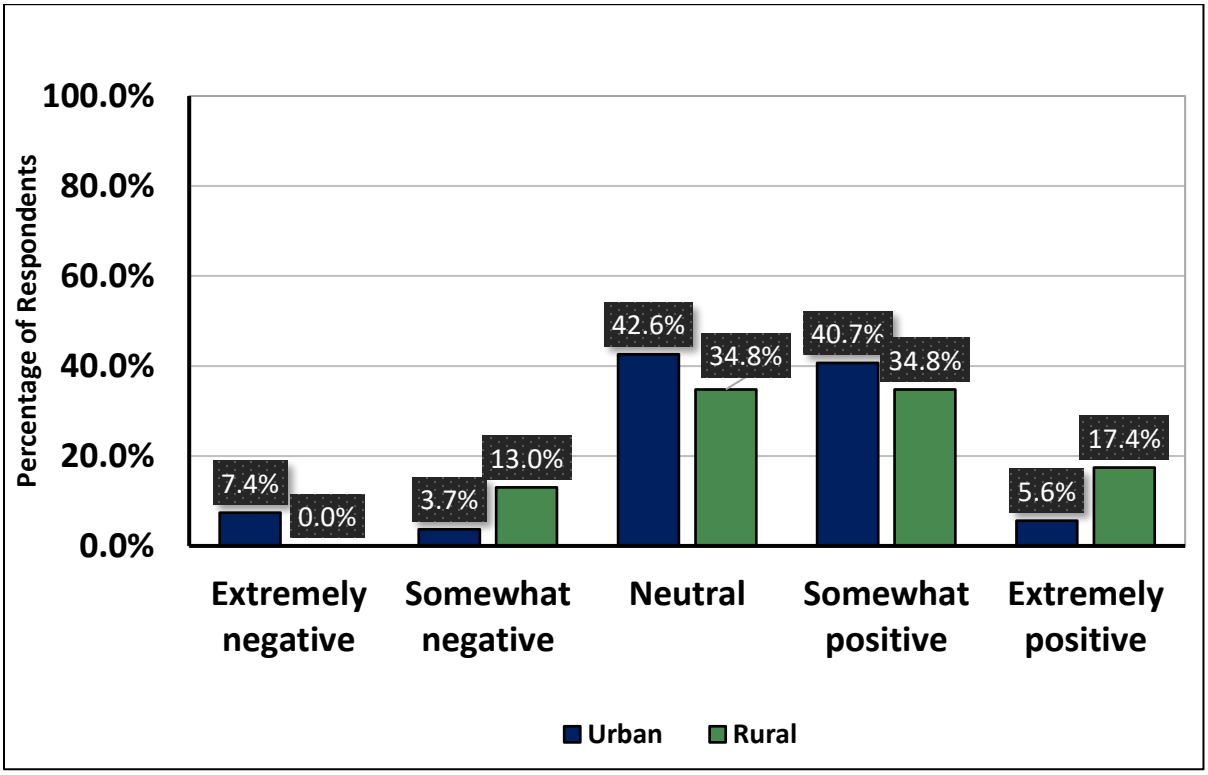

Figure 6.7. Overall opinion of using wood pellets for energy (n=77) (1= Extremely negative; 2= Somewhat negative; 3= Neutral; 4= Somewhat positive; 5= Extremely positive)

6.2.3. Environmental Perceptions of the Wood Pellet Manufacturing Industry

The questionnaire evaluated residents' trust and perceptions of the wood pellet manufacturing industry's environmental responsibility and impacts. Respondents were asked to rank their level of agreement on five-point Likert-type scales (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree). Table 6.5 summarizes urban and rural responses regarding five environmental statements dealing with the industry. Overall, respondents were generally neutral toward these statements. An independent sample two-tailed t-test revealed that the mean difference of one of these statements was statistically significant between urban and rural respondents at $\alpha = 0.05$ significance level. Rural

respondents more strongly agree that the industry is effective in its efforts to protect the environment.

Table 6.5. Environmental perceptions regarding the wood pellet manufacturing industry (n=79) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Urban $\bar{x}$	Rural $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
I trust the wood pellet manufacturing industry to act in the best interest of the environment.	3.2	3.2	*p*=.706
I think the wood pellet manufacturing industry utilizes appropriate forest management practices.	3.2	3.4	*p*=0.225
Currently, the wood pellet manufacturing industry is effective in its efforts to help protect the environment.	3.1	3.4	*p*=0.045*
Wood pellets are an environmentally superior alternative method of energy generation relative to fossil fuels.	3.1	3.5	*p*=0.051
Harvesting trees to manufacture wood pellets is not harmful to the environment.	2.8	3.3	*p*=0.061

Respondents were also asked to give their opinion of the impact that the wood pellet manufacturing industry has toward six environmental items on a five-point Likert-type scale (1= Extremely negative; 2= Somewhat negative; 3= Neutral; 4= Somewhat positive; 5= Extremely positive). The means of all respondents were averaged to create an environmental impact index. Table 6.6 summarizes rural and urban responses on these six items and the index. Items are ranked by least negatively impacted to most negatively impacted by average of the means with the index at the bottom. Using an independent sample two-tailed t-tests, two items were found to be significantly different between urban and rural respondents at $\alpha = 0.05$ significance level. The

industry's impact on "wildlife habitat" and "sustainable forests" was perceived more negatively by people that live in urban areas. Although the differences were not all statistically significant, respondents from urban areas reported that the industry more negatively impacted all environmental items compared to rural respondents.

Table 6.6. Opinions of the wood pellet manufacturing industry's environmental impacts (n=73) (1= Extremely negative; 2= Somewhat negative; 3= Neutral; 4= Somewhat positive; 5= Extremely positive)

	Urban $\bar{x}$	Rural $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
Sustainable Forests	2.9	3.4	p=0.012*
Forest-based Recreation	2.8	3.2	p=0.107
Soil Quality	2.9	3.1	p=0.287
Water Quality	2.9	3.1	p=0.206
Wildlife Habitat	2.7	3.2	p=0.018*
Air Quality	2.7	2.9	p=0.475
Environmental Impact Index	2.8	3.1	p=0.073

6.2.4 Social Perceptions of the Wood Pellet Manufacturing Industry

The questionnaire evaluated residents' perceptions of the wood pellet manufacturing industry's social concern and contribution toward local communities. Respondents were asked to rank their level of agreement on five-point Likert-type scales (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree). Table 6.7 summarizes urban and rural responses regarding six social statements dealing with the industry. Overall, respondents living in rural areas reported a higher level of agreement with all of the statements, indicating that rural respondents more approved of the industry's social interactions compared to urban respondents. These findings may be a result of the rural respondents' 50-mile proximity to and more intimate interactions with the industry. Independent sample two-tailed t-tests revealed

that four of the six statements were statistically significantly different between urban and rural respondents at $\alpha = 0.05$ significance level, including two mean differences that were statistically significant at $\alpha = 0.01$. Rural respondents more strongly agree that the wood pellet manufacturing industry "is concerned about the needs of communities", "is a good industry to work for", "creates quality jobs", and "is a superior industry for communities."

Table 6.7. Social perceptions regarding the wood pellet manufacturing industry (n=68) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Urban $\bar{x}$	Rural $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
Is concerned about the needs of communities.	2.8	3.3	*p*=0.030*
Contributes to community economic health.	3.1	3.4	*p*=0.112
Contributes to community activities and services.	2.9	3.1	*p*=0.132
Is a good industry to work for.	3.0	3.5	*p*=0.001**
Creates quality jobs.	3.2	3.7	*p*=0.002**
Is a superior industry for communities.	3.1	3.4	*p*=0.041*

Respondents were also asked to rank their level of concern regarding 11 social issues associated with converting wood to pellets for energy production; on five-point Likert-type scales (1= Not concerned at all; 2= Not very concerned; 3= Neutral; 4= Somewhat concerned; 5= Very concerned). The means of these 11 social issues were averaged for all respondents to create a production concern index. Although independent sample two-tailed t-tests did not reveal any statistically significant differences between urban and rural respondents at $\alpha = 0.05$

significance level, urban respondents had a higher production concern index of 3.5 compared to the rural 3.3, indicating that urban respondents were more concerned with production issues compared to rural. In fact, urban respondents were more concerned with seven of the 11 issues presented, including "Air pollution", "Forest degradation", "Soil degradation", "Damage to forest health", "Water pollution", "Safety due to increased road traffic", and "Noise pollution from pellet manufacturers."

Figures 6.8 and 6.9 present the social production concern issues ranked in order of highest to lowest concern for urban and rural respondents, respectively.

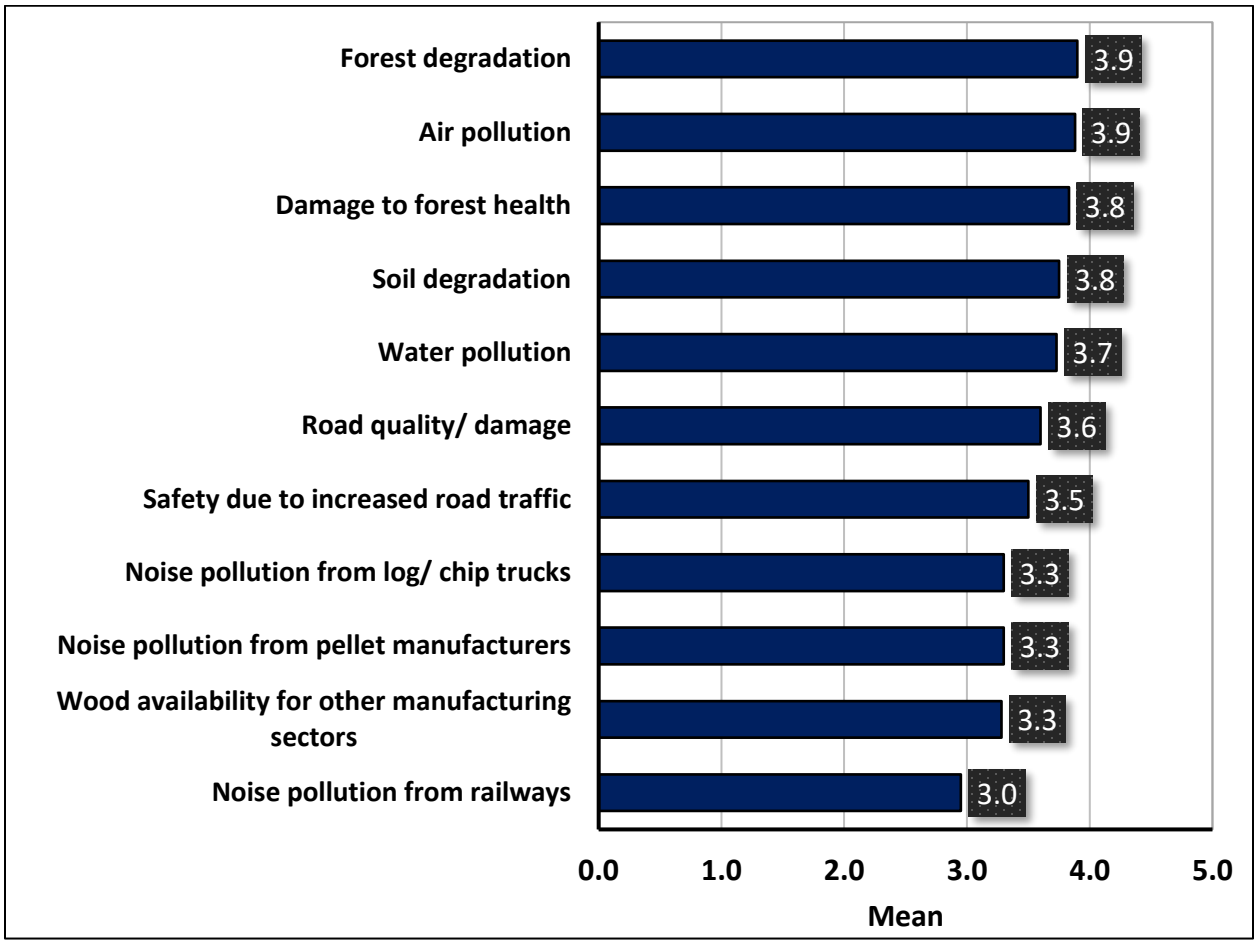

Figure 6.8. Social production concern issues of urban respondents (n=40) (1= Not concerned at all; 2= Not very concerned; 3= Neutral; 4= Somewhat concerned; 5= Very concerned)

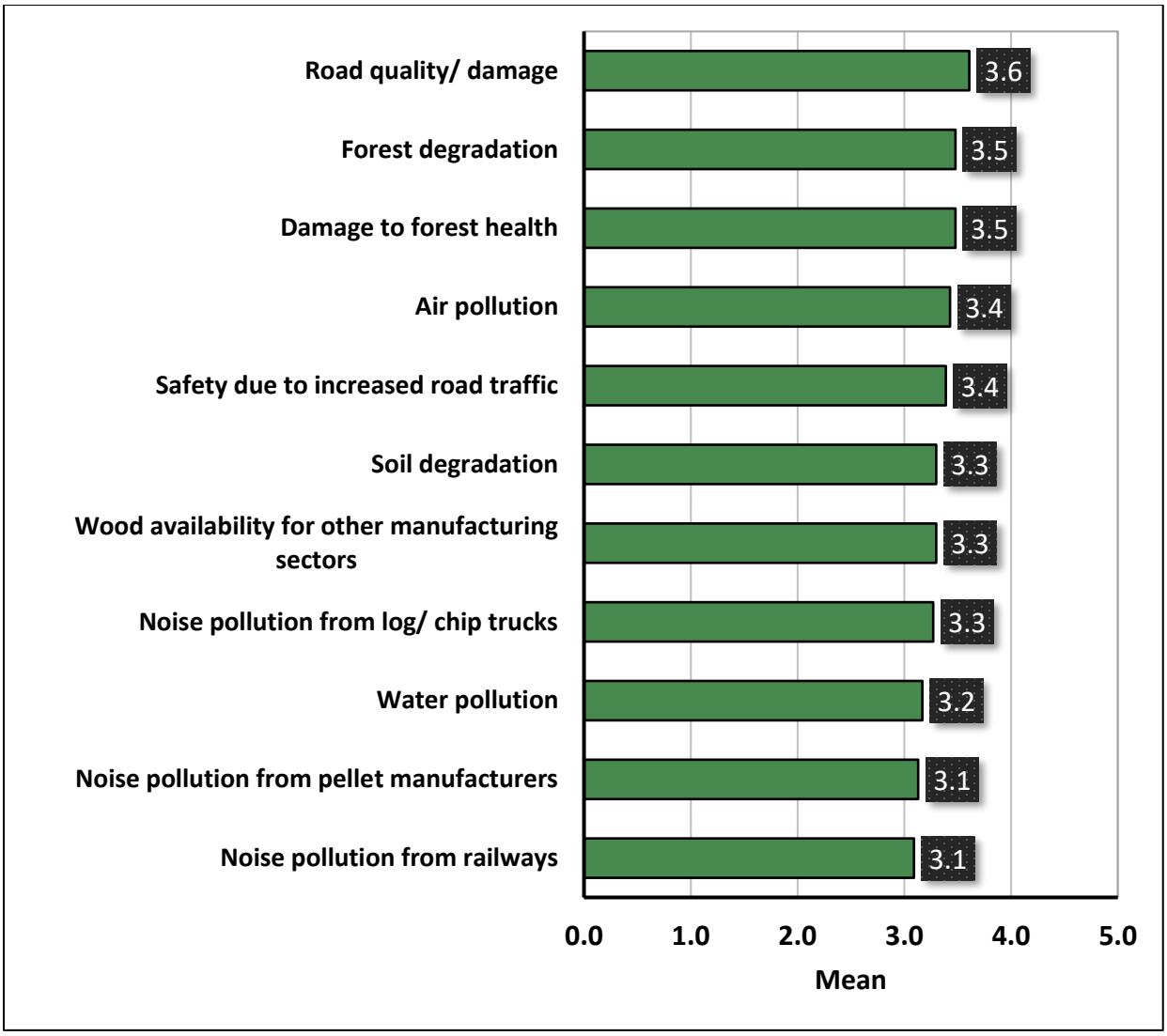

Figure 6.9. Social production concern issues of rural respondents (n=23) (1= Not concerned at all; 2= Not very concerned; 3= Neutral; 4= Somewhat concerned; 5= Very concerned)

6.2.5. Economic Perceptions of the Wood Pellet Manufacturing Industry

Of the 30.3% of respondents that owned forestland in their state of residence, 35% were urban respondents and 65% were rural. On average, respondents from urban areas owned 19 more acres of forestland compared to respondents from rural areas. Using an independent sample two-tailed t-test it was determined that there was no statistically significant difference at

$\alpha = 0.05$ significance level between urban and rural respondents regarding the amount of forestland owned.

Respondents were asked to indicate the types of financial support that they believe local, state, and federal governments should provide to the wood pellet manufacturing industry from a list that included "Property Tax Incentives", "Sales Tax Incentives", "Investment Tax Credits", Job Creation Incentives", and "Development Grants." Overall, state government received the largest proportion of responses from both urban (46.2%) and rural (43.1%) respondents across all items, indicating respondents from both areas thought government funding should primarily be provided by state governments.

6.2.6. Demographics

Table 6.8 reports the F-statistic and significance of on-way ANOVA test for the four continuous variables of population, age, education, and income as well as the value and asymptotic significance of Pearson's χ^2 test for the categorical variables of gender, ethnicity, and political affiliation.

Over 64% of urban respondents reported they lived in a city/ town with a population of over 10,001 compared to 34.8% of rural respondents (Figure 6.10). Using a one-way ANOVA test, it was determined that the difference in populations between urban and rural respondents was statistically significant at $\alpha = 0.01$ significance level. This was expected since urban respondents were within MSAs, which are highly populated.

Table 6.8. One-way ANOVA and χ^2 results for demographic variables

Demographic	F-Statistic	Significance (at α = 0.05)* (at α = 0.01)**	Demographic	Pearson's χ2 Value	Asymptotic Significance (at α = 0.05)* (at α = 0.01)**
Population of City/ Town	12.714	0.001**	Gender	3.102	0.078
Age	0.178	0.675	Ethnicity	8.819	0.066
Level of Education	1.861	0.177	Political Affiliation	9.249	0.026*
Level of Income	3.326	0.073			

a. 20% of cells have expected count <5

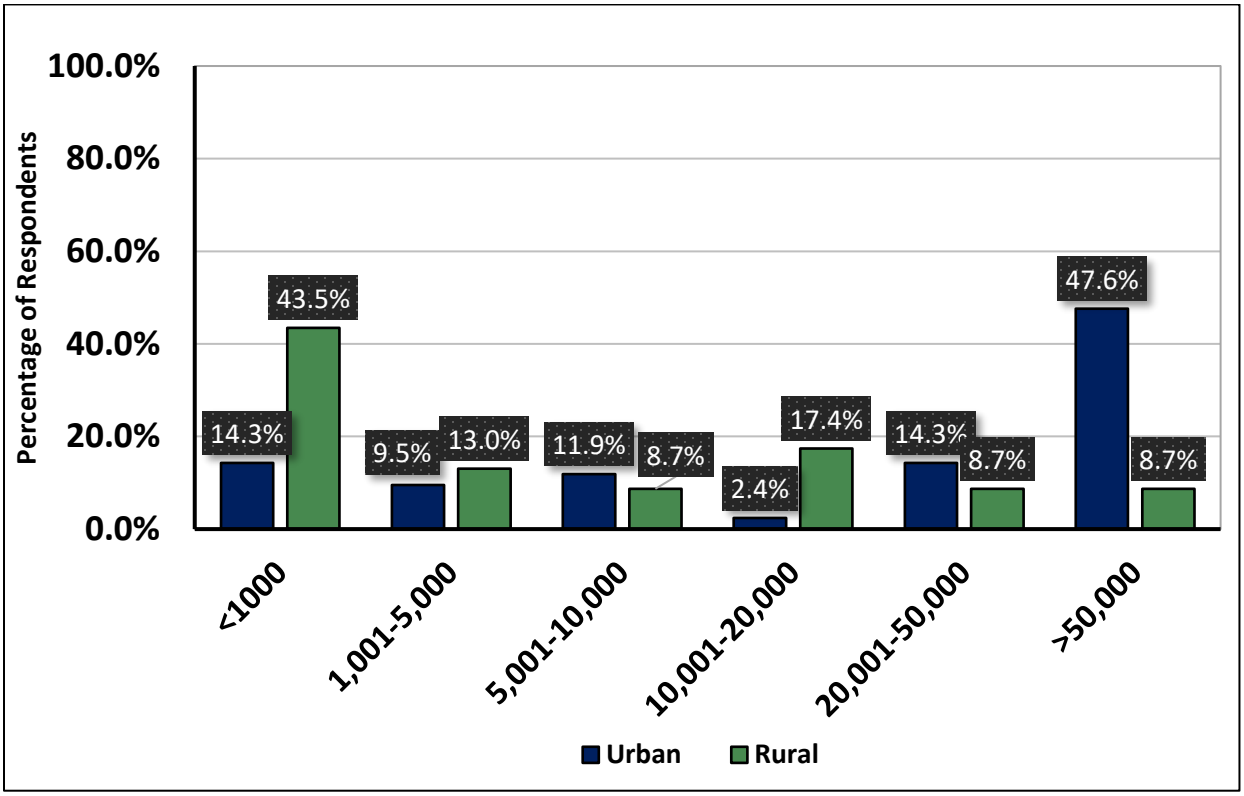

Figure 6.10. Population of respondent City/ Town (n=65)

A one-way ANOVA did not find any statistically significant difference between urban and rural respondents and age at $\alpha = 0.05$ significance level. Age was roughly even among urban and rural respondents (Figure 6.11).

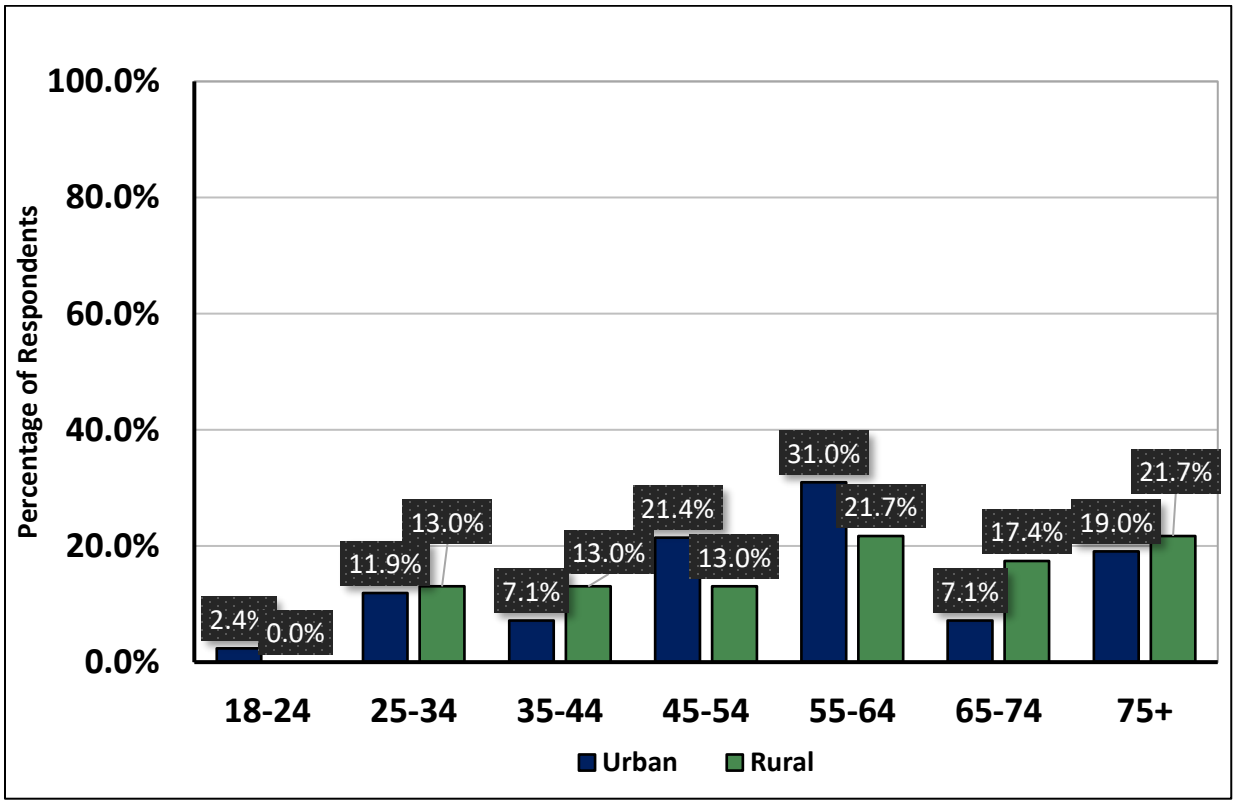

Figure 6.11. Age of respondents (n=65)

Using Pearson's χ^2 test, no statistically significant association was found between gender and urban/rural classification of respondents at $\alpha = 0.05$ significance level. However, more males responded from rural areas at 60.9% compared to the predominantly female respondents from urban areas at 61.9% (Figure 6.12). Similarly, using a one-way ANOVA, no statistically significant difference was found between the level of education of urban and rural respondents at $\alpha = 0.05$ significance level. However, urban respondents were more educated as 73.8% had a college degree or higher compared to the 52.2% of rural respondents (Figure 6.13). This result was to be expected due to the association of rural areas with marginalization.

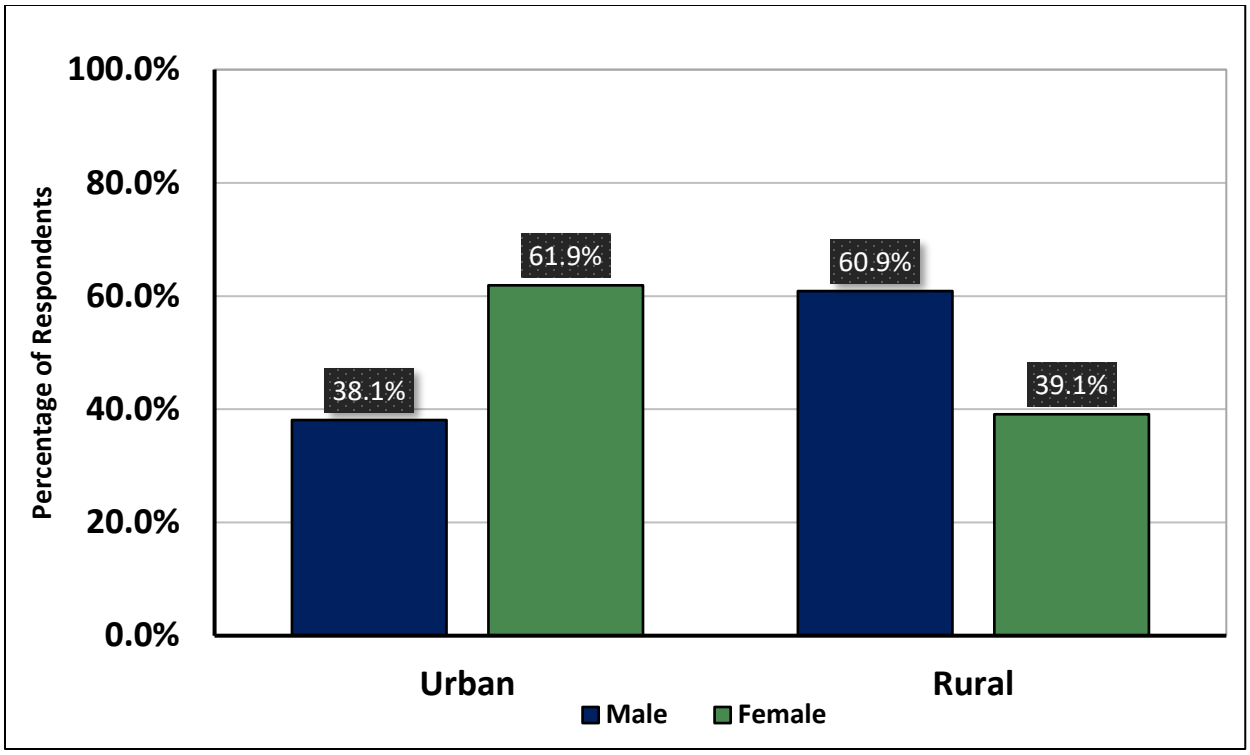

Figure 6.12. Gender of respondents (n=65)

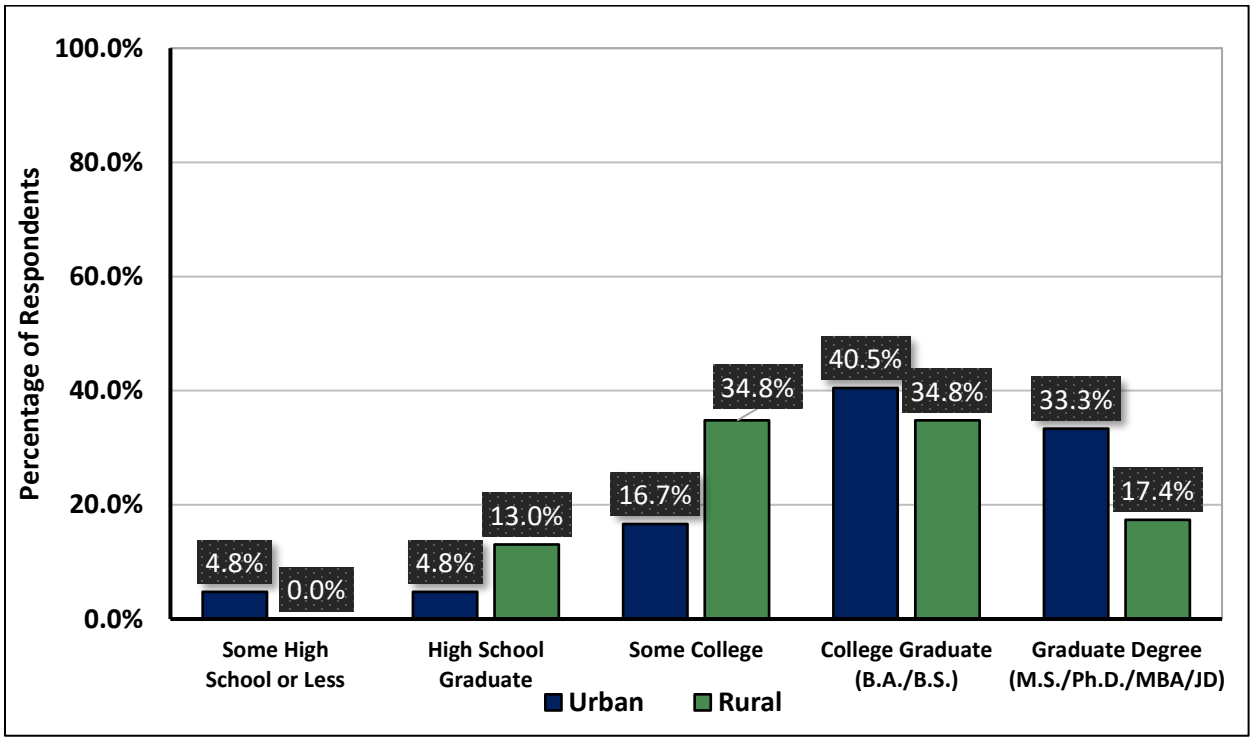

Figure 6.13. Respondent level of education (n=65)

No statistically significant association was found between ethnicity and urban/rural classification of respondents at $\alpha = 0.05$ significance level using Pearson's χ^2 test. Respondents from both areas were predominantly white (Figure 6.14). Similarly, using a one-way ANOVA, no statistically significant difference was found between the level of income of urban and rural respondents at $\alpha = 0.05$ significance level. However, the p-value was close to $\alpha = 0.05$ at p= 0.073. Nearly 48% of rural respondents had a household income of less than $80,000 compared to the urban 25% (Figure 6.15). Comparable to level of education, this result was to be expected because of the marginalization associated with rural areas.

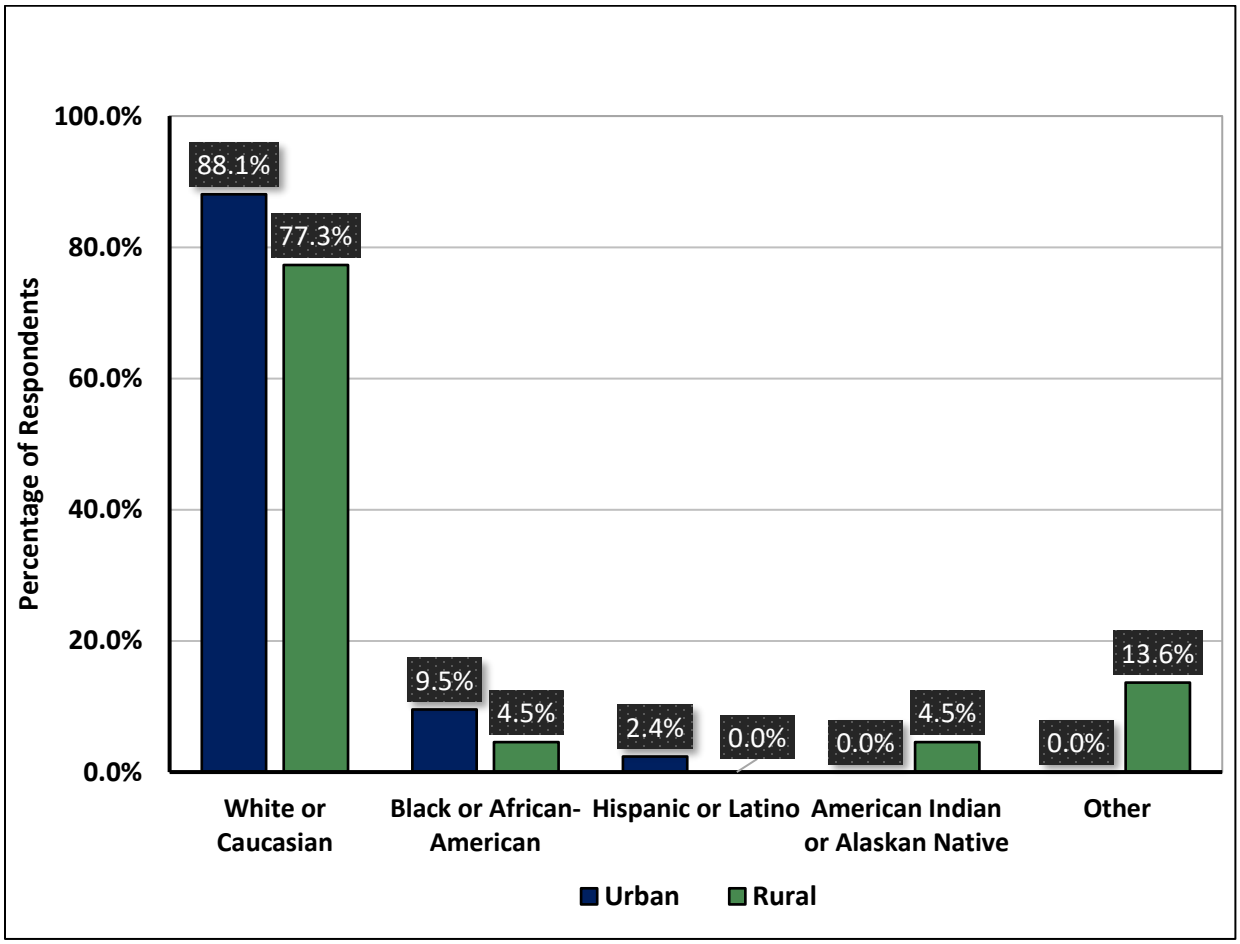

Figure 6.14. Ethnicity of respondents (n=64)

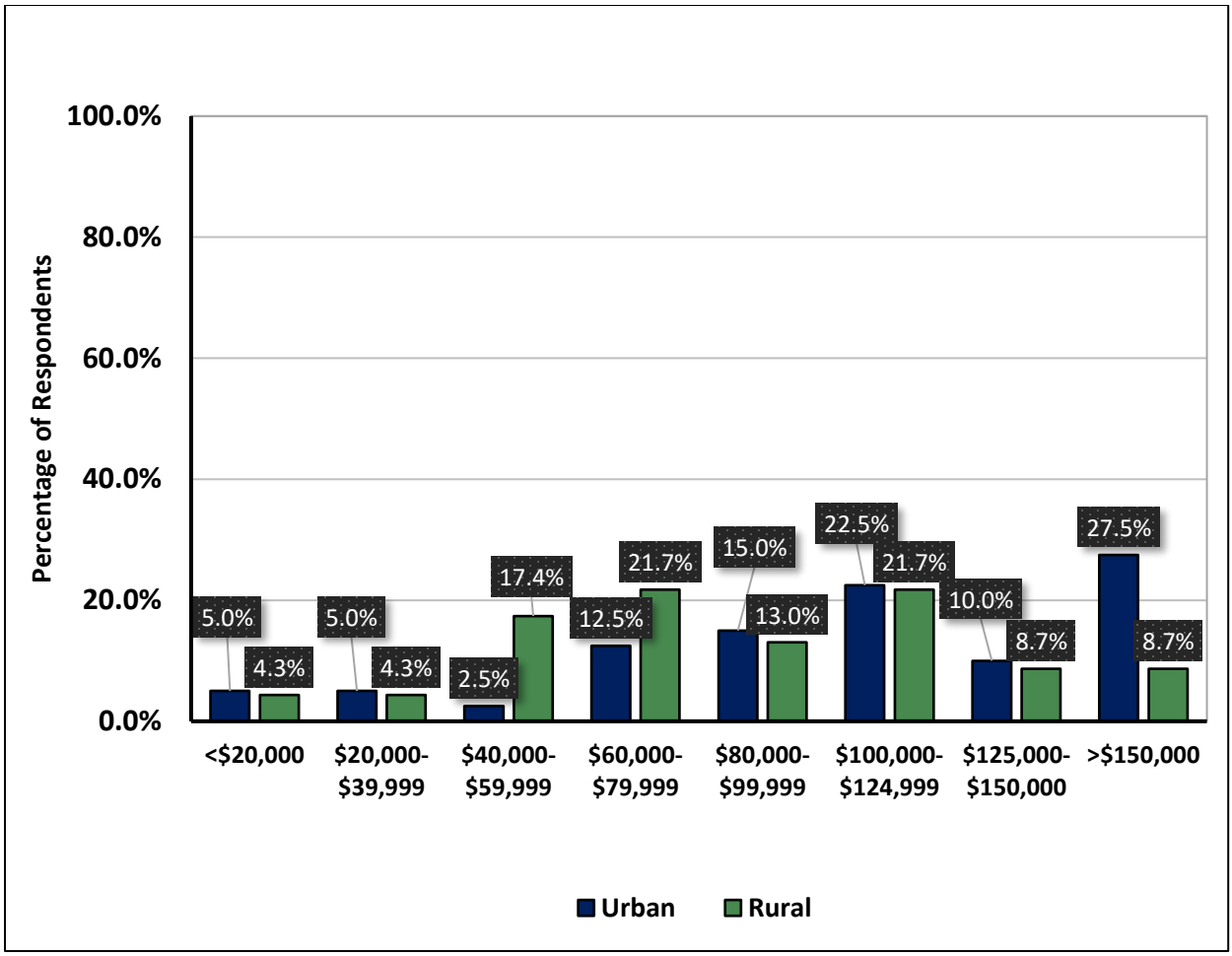

Figure 6.15. Respondent level of income (n=63)

Lastly, a Pearson's χ^2 test revealed a statistically significant association between political affiliation and urban/rural classification of respondents at $\alpha = 0.05$ significance level. Urban respondents were only 35.7% republican compared to the rural 43.5% (Figure 6.16). Even more contrasting is the proportion of democrat respondents between the areas. Over 45% of urban respondents reported they were democrats compared to the 13% of rural respondents. This result was unsurprising being that urban areas are typically more liberal in ideology.

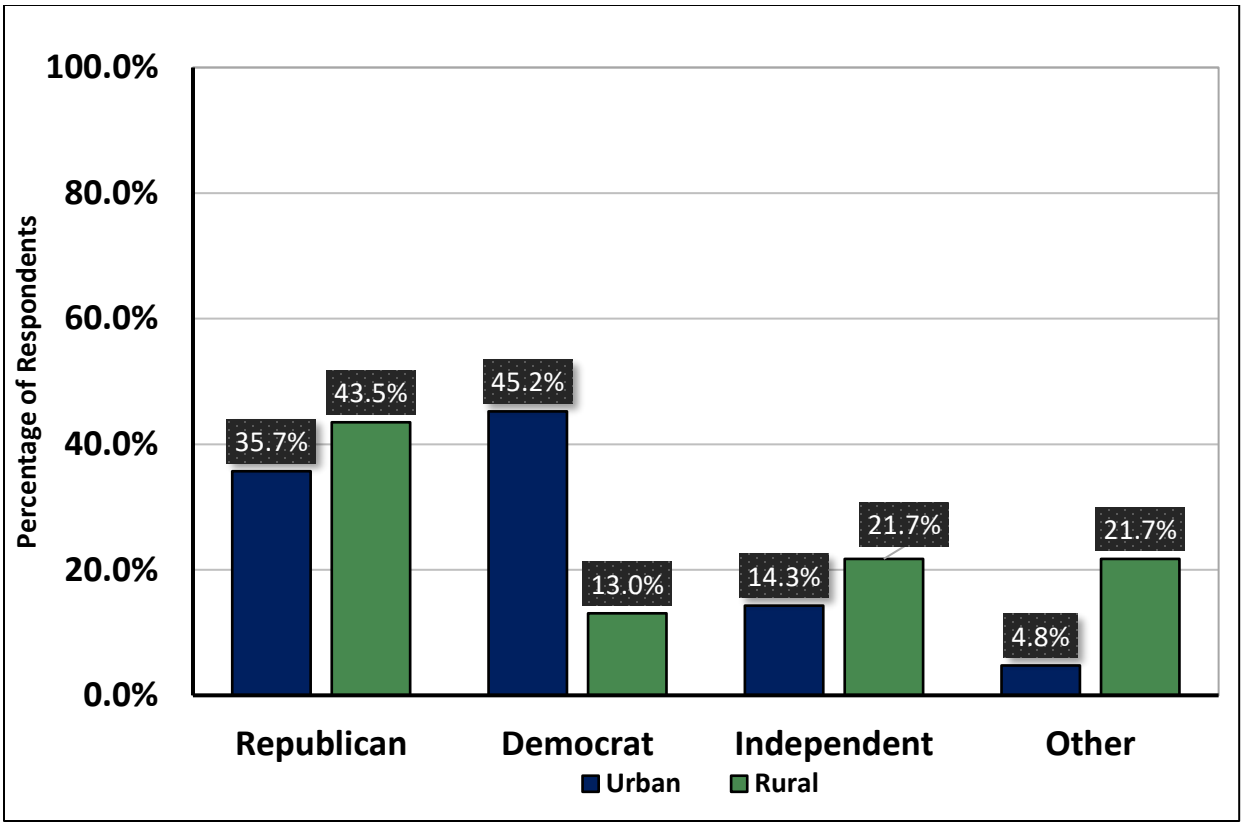

Figure 6.16. Political affiliation of respondents (n=65)

6.3. Gulf Coast and Atlantic Coast Comparison

6.3.1. Introduction

Although this thesis focused on five states that contained selected wood pellet mills (LA, MS, NC, SC, & VA), due to the geographic border of the two largest MSAs of each state, respondents from Maryland, Washington DC, Tennessee, and West Virginia were included. Therefore, the Gulf Coast region contained the states of Louisiana, Mississippi, and Tennessee, and the Atlantic Coast contained the states of Maryland, North Carolina, South Carolina, Virginia, Washington DC, and West Virginia. As mentioned in the methodology section of this thesis, the Gulf Coast region contained three Drax Biomass mills that primarily used softwood feedstock and the Atlantic Coast region contained three Enviva mills that primarily used

hardwood feedstock (Figure 6.17). Of the 122 respondents, 39.2% were from the Gulf Coast and 60.7% were from the Atlantic Coast.

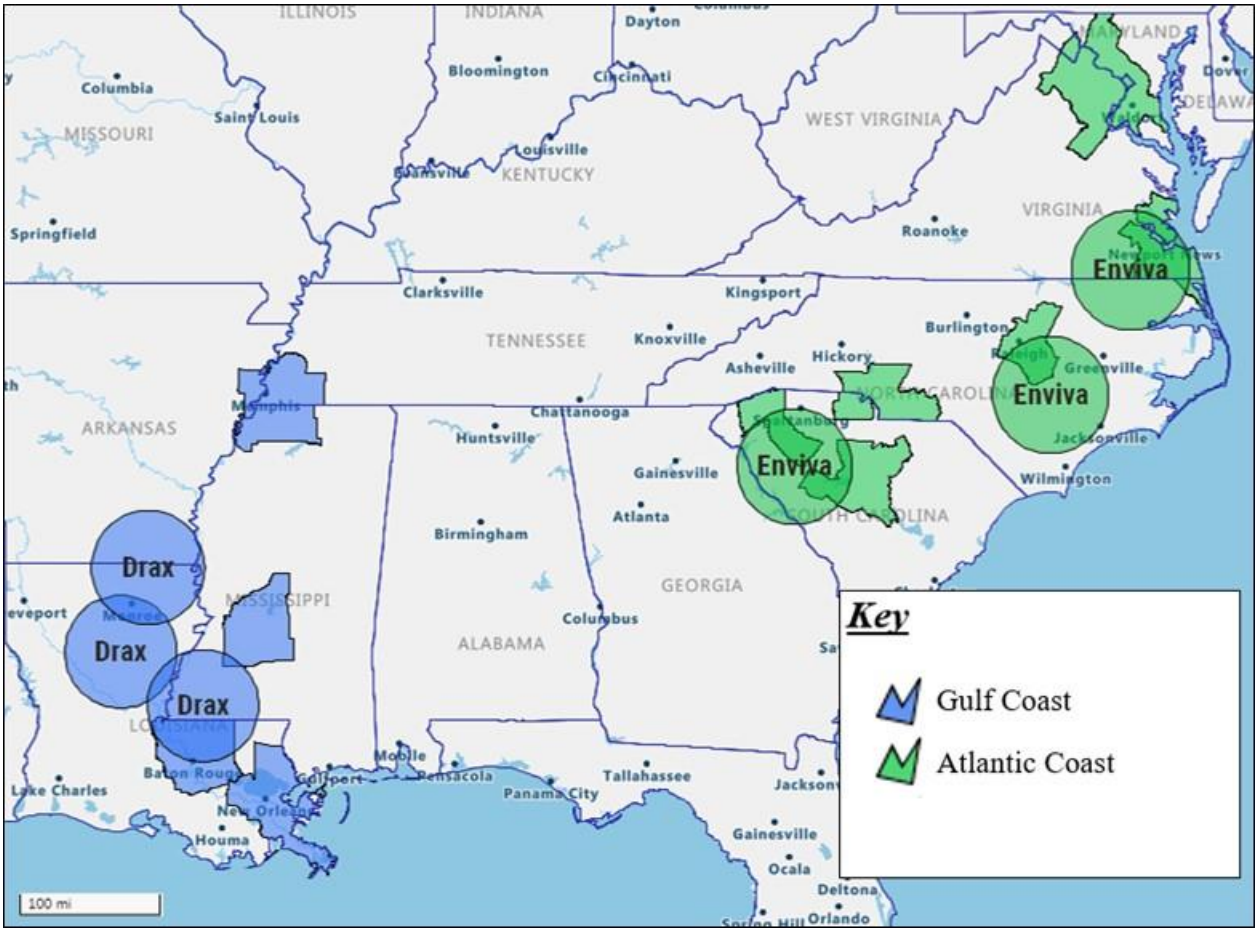

Figure 6.17. Map of Gulf Coast and Atlantic Coast regions

6.3.2. Wood Pellet Manufacturing Industry Awareness

Using an independent sample two-tailed t-test, no statistically significant difference was found at $\alpha = 0.05$ significance level between Gulf Coast and Atlantic Coast respondents for awareness of the wood pellet manufacturing industry (Figure 6.18). The mean response to this question was 2.4 for Gulf Coast respondents and 2.5 for Atlantic Coast respondents on a five-point Likert-type scale, indicating a generally low awareness for both regions (1=Not at all aware; 2= Not very aware; 3= Neither aware nor unaware; 4= Somewhat aware; 5= Very aware).

When asked if they were aware of any pellet manufacturers, 39.3% of Gulf Coast respondents reported they were compared to 28.9% of Atlantic Coast respondents.

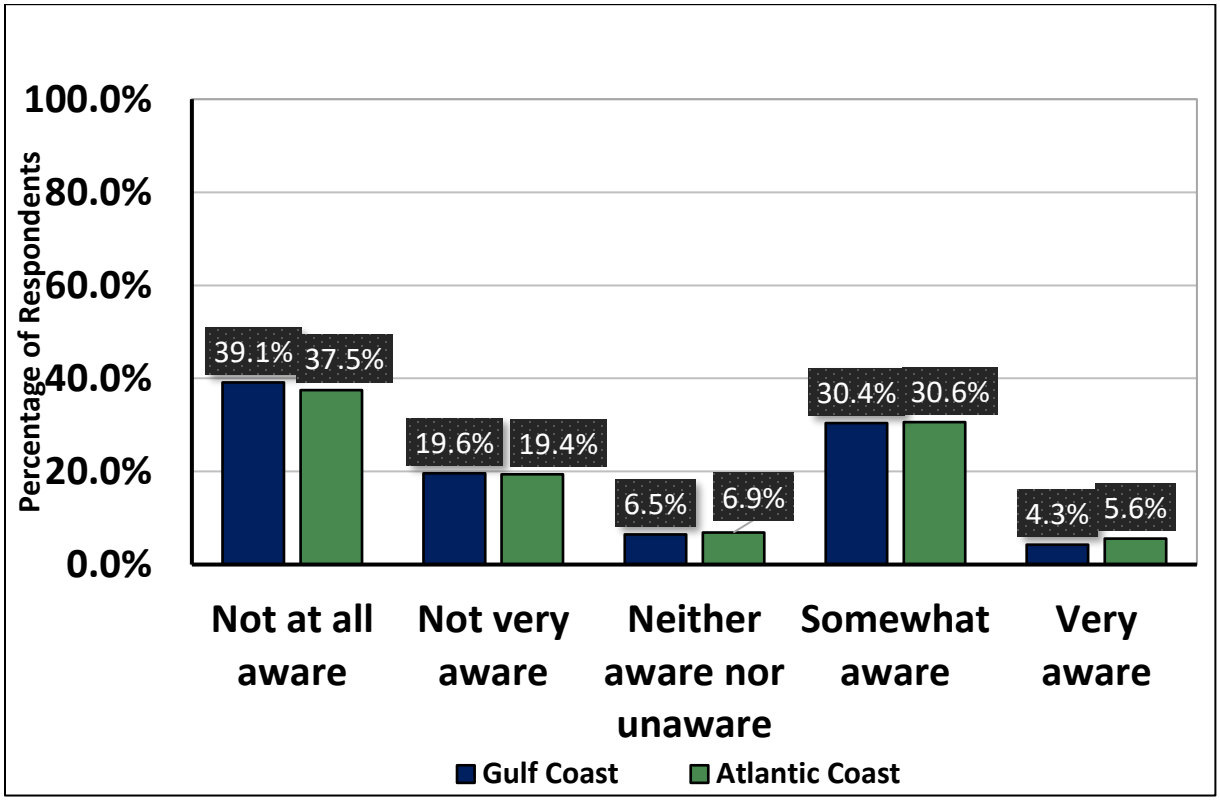

Figure 6.18. Awareness of the wood pellet manufacturing industry (n=118) (1=Not at all aware; 2= Not very aware; 3= Neither aware nor unaware; 4= Somewhat aware; 5= Very aware)

Independent sample two-tailed t-tests were employed to examine whether the awareness and knowledge of pellet manufacturers and industry differed between the regions (Table 6.9). The mean differences of both items were not statistically significant between Gulf Coast and Atlantic Coast respondents at $\alpha = 0.05$ significance level. However, even though Gulf Coast respondents had a higher mean for both statements, the means for both regions were below the neutral point of three indicating respondents from neither region claimed to be aware of in-state manufacturers or very knowledgeable about the industry.

Table 6.9. Awareness and knowledge of the wood pellet manufacturing industry (n=68) (1=Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

Item	Gulf Coast $\bar{x}$	Atlantic Coast $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
I am aware of wood pellet manufacturers in my state.	2.8	2.3	p=0.184
I am very knowledgeable about the wood pellet manufacturing industry.	2.2	1.9	p=0.274

Figures 6.19 and 6.20 present what Gulf Coast and Atlantic Coast respondents think wood pellets are made from and what they are used for, respectively. Both figures are ranked in descending order based on Gulf Coast responses.

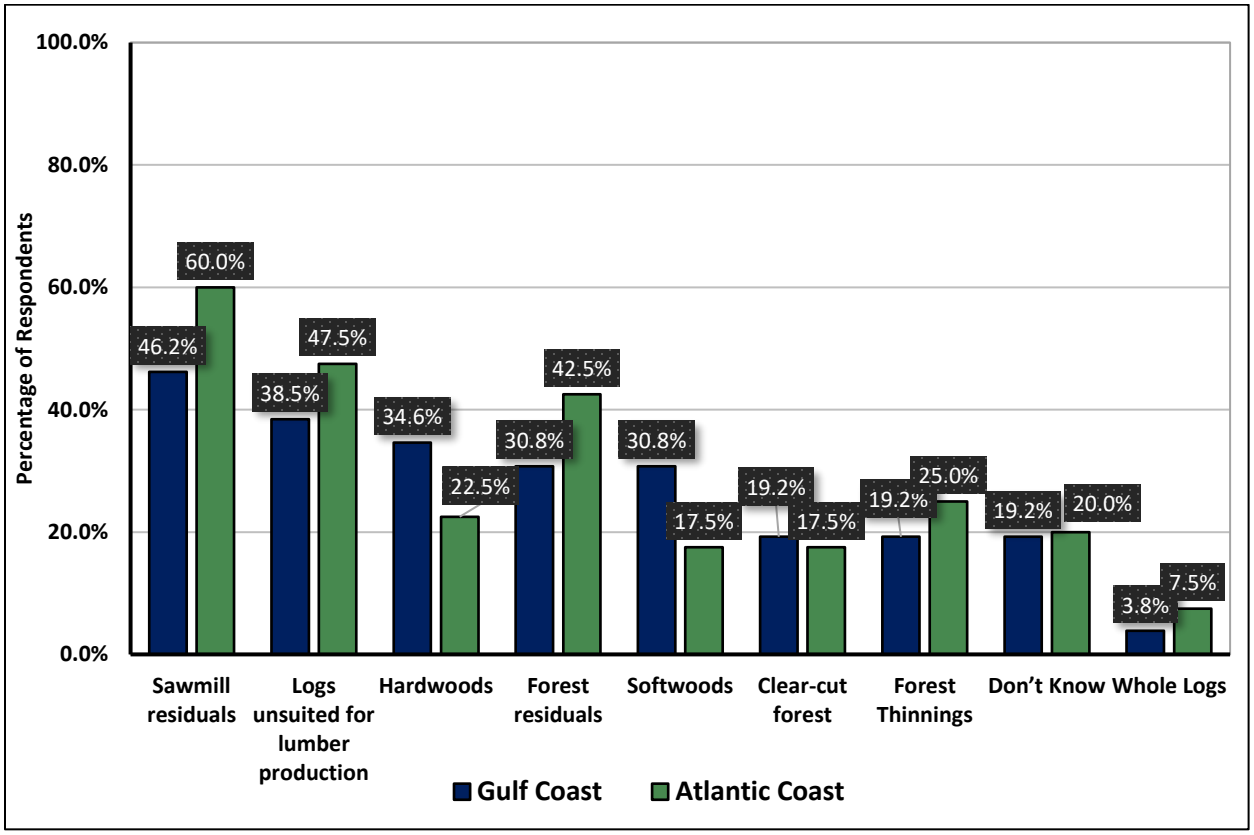

Figure 6.19. What Gulf Coast and Atlantic Coast respondents think wood pellets are made from (n=66) (Multiple responses possible)

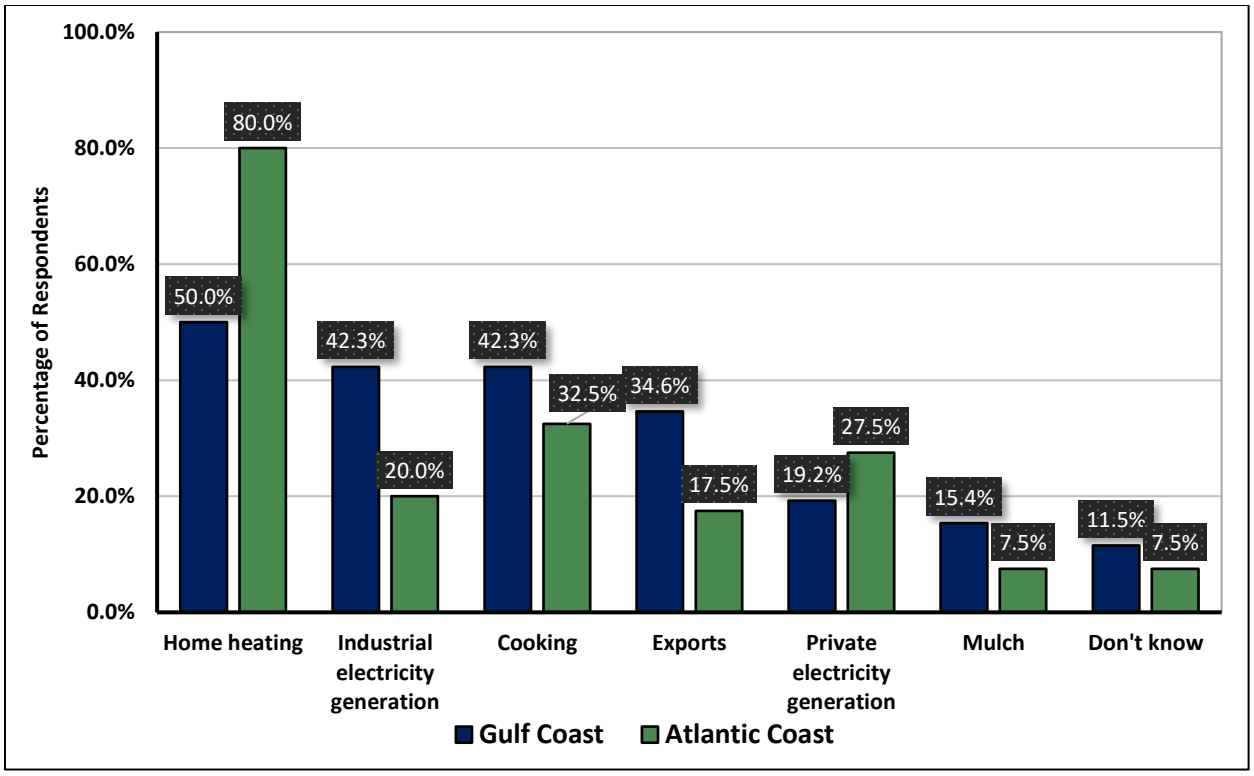

Figure 6.20. What Gulf Coast and Atlantic Coast respondents think wood pellets are used for (n=66)(Multiple responses possible)

6.3.3. General Environmental, Social, and Economic Perceptions

Respondents were asked to rank their level of agreement for three banks of statements to reveal general environmental, social, and economic perceptions on five-point Likert-type scales (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree). Tables 6.10, 6.11, and 6.12 summarize the results by providing mean responses between Gulf Coast and Atlantic Coast respondents as well as P-values from independent sample two-tailed t-tests between means.

Two items were statistically significantly different between regional respondents at $\alpha = 0.05$ significance level for the adapted version of the New Environmental Paradigm scale (Dunlap et al., 2000) (Table 6.10). For these two items, Atlantic Coast respondents reported a statistically significantly higher environmental affinity. Atlantic Coast respondents more

strongly disagreed that "climate change caused by humans has been greatly exaggerated." They more strongly agreed that "humans are accelerating the rate of global warming."

Regarding the differences of the eight items that were not statistically significant, the means showed that the two regions had different relationships to the environment. Gulf Coast respondents did not agree as much as Atlantic Coast respondents that "If things continue on their present course, we will soon experience a major climate change catastrophe." However, they more strongly disagreed that "Humans have the right to modify the environment to suit their needs" and "The balance of nature is strong enough to cope with the impacts of industrialization."

Table 6.10. Environmental affinity of respondents (n=98) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Gulf Coast $\bar{x}$	Atlantic Coast $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
Humans have the right to modify the environment to suit their needs.	2.5	2.7	*p*=0.316
Human economic needs are more important than protecting the environment.	2.0	2.1	*p*=0.491
When humans interfere with the environment it often produces disastrous consequences.	3.7	3.9	*p*=0.303
The balance of nature is strong enough to cope with the impacts of industrialization.	1.9	2.3	*p*=0.094
Humans are accelerating the rate of global warming.	3.1	3.8	*p*=0.01*
Climate change caused by humans has been greatly exaggerated.	3.4	2.6	*p*=0.003**
Humans were meant to rule over the rest of nature.	2.4	2.4	*p*=0.962
Humans will eventually learn enough about global warming to be able to control it.	2.7	2.7	*p*=0.814
If things continue on their present course, we will soon experience a major climate change catastrophe.	3.0	3.5	*p*=0.072
Climate change is a naturally occurring phenomena, not caused by humans.	3.0	2.6	*p*=0.089

In the social/ community issues scale, three items were found to be statistically significantly different between the two regions at $\alpha = 0.05$ significance level, including two that were significantly different at $\alpha = 0.01$ (Table 6.11). Atlantic Coast respondents more strongly agreed that "It is important to me that the companies in my community do not harm the environment", "I/my family recycles materials such as glass, plastic, and paper", and "My community has a recycling program in place for materials such as glass, plastic, and paper." Respondents from both regions were generally concerned about natural resources within their community and were generally willing to be inconvenienced in order to positively affect their community. However, while all mean differences were not statistically significant, Atlantic Coast respondents more strongly agreed with all statements compared to Gulf Coast Respondents.

Table 6.11. General social perceptions of respondents (n=93) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Gulf Coast $\bar{x}$	Atlantic Coast $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
It is important to me that the companies in my community do not harm the environment.	4.1	4.4	p=0.049*
I/my family recycles materials such as glass, plastic, and paper.	3.4	4.2	p=0.001**
My community has a recycling program in place for materials such as glass, plastic, and paper.	2.7	4.4	p=0.000**
I am generally concerned about the natural resources in my community such as forest, air, and water.	4.2	4.4	p=0.311
I am willing to be inconvenienced in order to participate in recycling that is environmentally friendly in my community.	3.8	4.1	p=0.306

One item in the general economic scale was found to be statistically significantly different at $\alpha = 0.05$ significance level between respondents from the two regions (Table 6.12). Atlantic Coast respondents more strongly agreed that their community has a strong economy. Although the mean differences were not all statistically significant, Atlantic Coast respondents also more strongly agreed that governments should provide financial support to develop local businesses compared to Gulf Coast respondents, who slightly agreed more that industry should stand on its own.

Table 6.12. General economic perceptions of respondents (n=91) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Gulf Coast $\bar{x}$	Atlantic Coast $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
Job creation is important to my community.	4.5	4.2	*p*=0.199
My community has a strong economy.	3.3	3.8	*p*=0.036*
A strong economy is important to my community.	4.4	4.5	*p*=0.868
Local government should provide financial support to develop/ maintain businesses in my community.	2.9	3.4	*p*=0.114
State government should provide financial support to develop/ maintain businesses in my community.	2.9	3.4	*p*=0.072
The Federal Government should provide financial support to develop/ maintain businesses in my community.	3.0	3.2	*p*=0.448
Industry should stand on its own without government support/ intervention.	3.4	3.3	*p*=0.897

Respondents were asked to provide their level of agreement on a five-point Likert-type scale regarding the need for different sources of energy to be a priority in the US. According to

independent sample two-tailed t-tests, no statistically significant difference was found between Gulf Coast and Atlantic Coast respondents at $\alpha = 0.05$ significance level. The means of both regions ranked solar followed by hydro energy to be the highest priorities, while woody biomass ranked second to last for Gulf Coast respondents and fourth to last for Atlantic Coast respondents. Coal was the least prioritized for both groups (Figure 6.21).

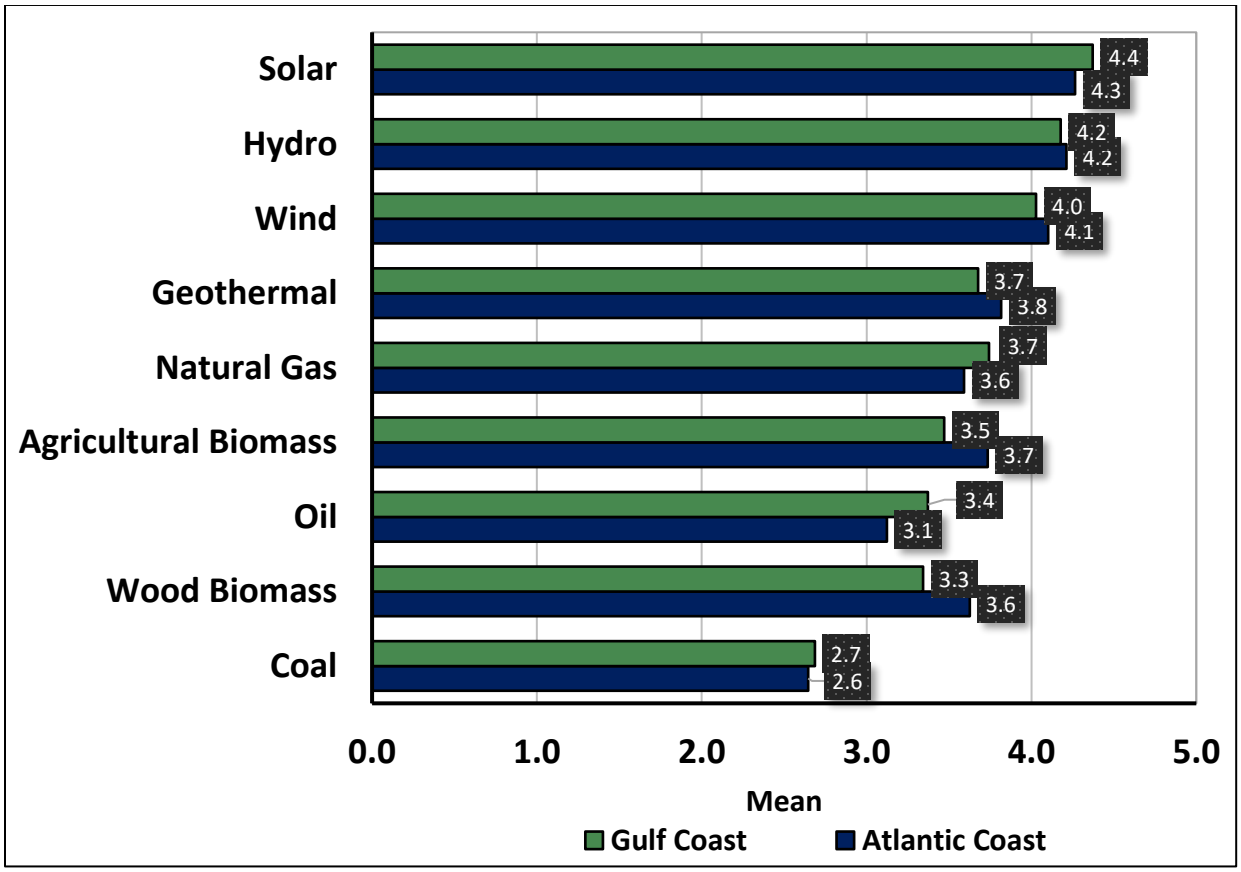

Figure 6.21. Different sources of United States energy ranked by respondent priority (n=84) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

Respondents were also asked for their level of agreement regarding wood pellets as a viable energy alternative to fossil fuels. No statistically significant difference was found at $\alpha = 0.05$ significance level; the means were 3.2 for respondents of both regions on a five-point Likert-type scale (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree;

5= Strongly agree), indicating both groups slightly agreed. Similarly, the overall opinion of using wood pellets for energy was not statistically significantly different at $\alpha = 0.05$ significance level between regions; the means were 3.4 for respondents of both regions on a five-point Likert-type scale (Figure 6.22). Both regions had a generally positive opinion of using wood pellets for energy with 45.2% of Gulf Coast and 50% of Atlantic Coast respondents reporting either somewhat positive or extremely positive.

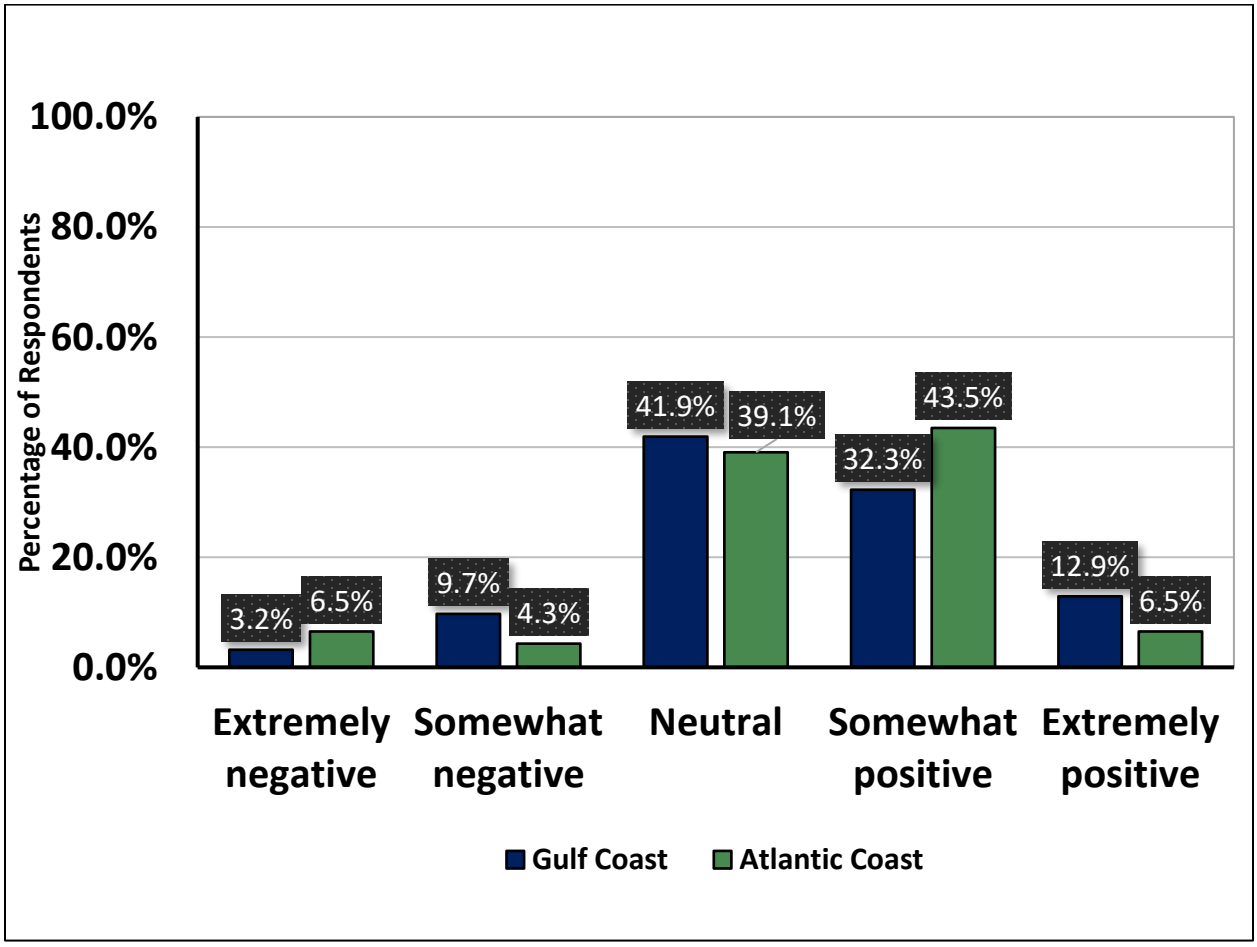

Figure 6.22. Overall opinion of using wood pellets for energy (n=77) (1= Extremely negative; 2= Somewhat negative; 3= Neutral; 4= Somewhat positive; 5= Extremely positive)

6.3.3. Environmental Perceptions of the Wood Pellet Manufacturing Industry

Table 6.13 summarizes Gulf Coast and Atlantic Coast responses regarding five environmental statements dealing with the industry. Overall, respondents were generally neutral toward these statements. Using independent sample two-tailed t-tests, no mean differences were found to be statistically significant at $\alpha = 0.05$ significance level between regions. However, while not statistically significantly different, Atlantic Coast respondents disagreed more that "Harvesting trees to manufacture wood pellets is not harmful to the environment."

Table 6.13. Environmental perceptions regarding the wood pellet manufacturing industry (n=79) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Gulf Coast $\bar{x}$	Atlantic Coast $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
I trust the wood pellet manufacturing industry to act in the best interest of the environment.	3.2	3.1	*p*=0.624
I think the wood pellet manufacturing industry utilizes appropriate forest management practices.	3.3	3.2	*p*=0.625
Currently, the wood pellet manufacturing industry is effective in its efforts to help protect the environment.	3.2	3.1	*p*=0.287
Wood pellets are an environmentally superior alternative method of energy generation relative to fossil fuels.	3.3	3.2	*p*=0.314
Harvesting trees to manufacture wood pellets is not harmful to the environment.	3.2	2.8	*p*=0.115

Regarding opinions of the impact that the wood pellet manufacturing industry has toward the environment, table 6.14 summarizes Gulf Coast and Atlantic Coast responses on six items, followed by the environmental impact index. Items are ranked by least negatively impacted to most negatively impacted by average of the means. Using an independent sample two-tailed t-

tests, five items were found to be significantly different between Gulf Coast and Atlantic Coast respondents at $\alpha = 0.05$ significance level, including the environmental impact index. The industry's impact on "sustainable forest", "forest-based recreation", "soil quality", and "air quality was perceived more negatively by respondents from the Atlantic Coast. Respondents from the Atlantic Coast reported that the industry more negatively impacted all environmental items compared to Gulf Coast respondents; indicated by the lower means and the statistically significant difference of the environmental impact index.

Table 6.14. Opinions of the wood pellet manufacturing industry's environmental impacts (n=73) (1= Extremely negative; 2= Somewhat negative; 3= Neutral; 4= Somewhat positive; 5= Extremely positive)

	Gulf Coast $\bar{x}$	Atlantic Coast $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
Sustainable Forests	3.3	2.8	p=0.019*
Forest-based Recreation	3.3	2.6	p=0.003**
Soil Quality	3.2	2.7	p=0.011*
Water Quality	3.1	2.8	p=0.112
Air Quality	3.0	2.6	p=0.042*
Wildlife Habitat	2.9	2.8	p=0.608
Environmental Impact Index	3.2	2.7	p=0.004**

6.3.4. Social Perceptions of the Wood Pellet Manufacturing Industry

Table 6.15 summarizes Gulf Coast and Atlantic Coast responses regarding six social statements dealing with the industry. Overall, respondents from the Gulf Coast reported a higher level of agreement with all of the statements, indicating that they more approved of the industry's social interactions compared to Atlantic Coast respondents. Independent sample two-tailed t-tests revealed that two statements were statistically significantly different between Gulf Coast and Atlantic Coast respondents at $\alpha = 0.05$ significance level. Gulf Coast respondents

more strongly agreed that the wood pellet manufacturing industry "creates quality jobs" and "is a superior industry for communities."

Table 6.15. Social perceptions regarding the wood pellet manufacturing industry (n=68) (1= Strongly disagree; 2= Somewhat disagree; 3= Neutral; 4= Somewhat agree; 5= Strongly agree)

	Gulf Coast $\bar{x}$	Atlantic Coast $\bar{x}$	Significance (at α=0.05)* (at α=0.01)**
Is concerned about the needs of communities.	3.1	2.9	p=0.381
Contributes to community economic health.	3.4	3.1	p=0.067
Contributes to community activities and services.	3.1	2.8	p=0.055
Is a good industry to work for.	3.3	3.1	p=0.163
Creates quality jobs.	3.6	3.2	p=0.018*
Is a superior industry for communities.	3.4	3.0	p=0.014*

Gulf Coast and Atlantic Coast respondent levels of concern for 11 social issues associated with converting wood to pellets for energy production are presented in Figures 6.23 and 6.24; ranked in order of highest to lowest concern. The means of these 11 social issues were averaged for all respondents to create a production concern index. Independent sample two-tailed t-tests did not reveal any statistically significant differences between Gulf Coast and Atlantic Coast respondents at $\alpha = 0.05$ significance level. However, although not statistically significantly different, Atlantic Coast respondents had a higher production concern index of 3.5 compared to the Gulf Coast 3.4, indicating that Atlantic Coast respondents were slightly more concerned with production issues compared to Gulf Coast respondents. In fact, Atlantic Coast respondents were more concerned with all of the issues presented besides "Road quality/ damage."

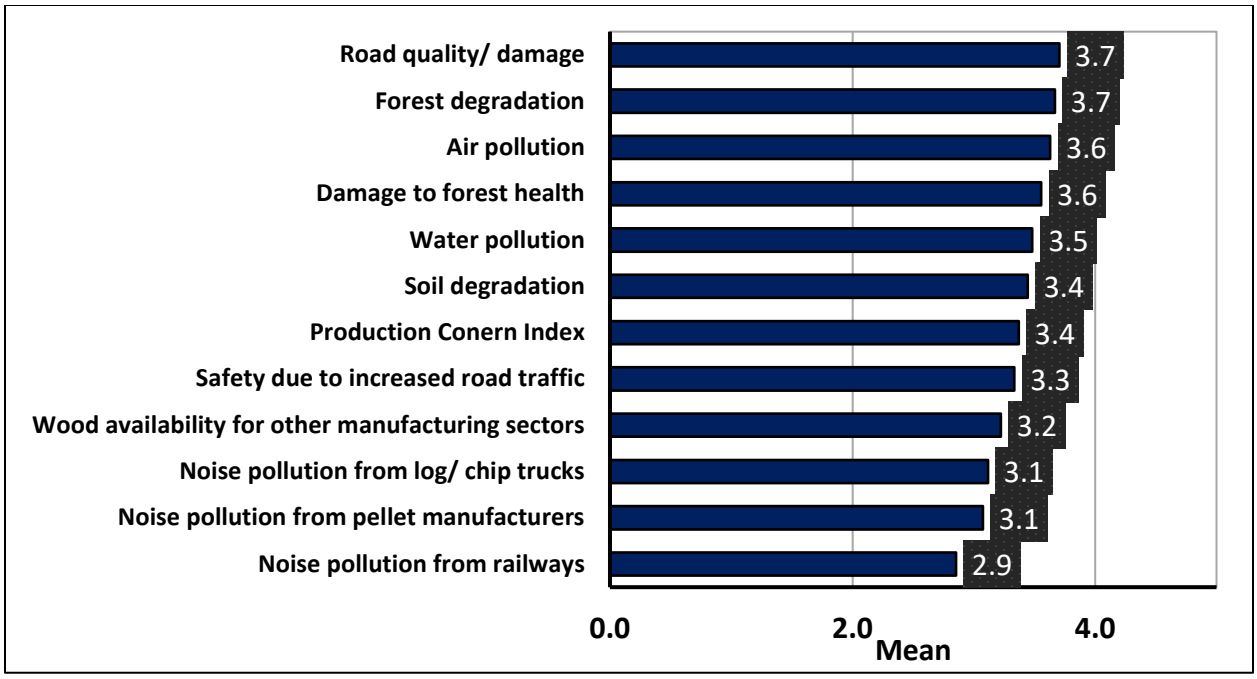

Figure 6.23. Social production concern issues of Gulf Coast respondents (n=27) (1= Not concerned at all; 2= Not very concerned; 3= Neutral; 4= Somewhat concerned; 5= Very concerned)

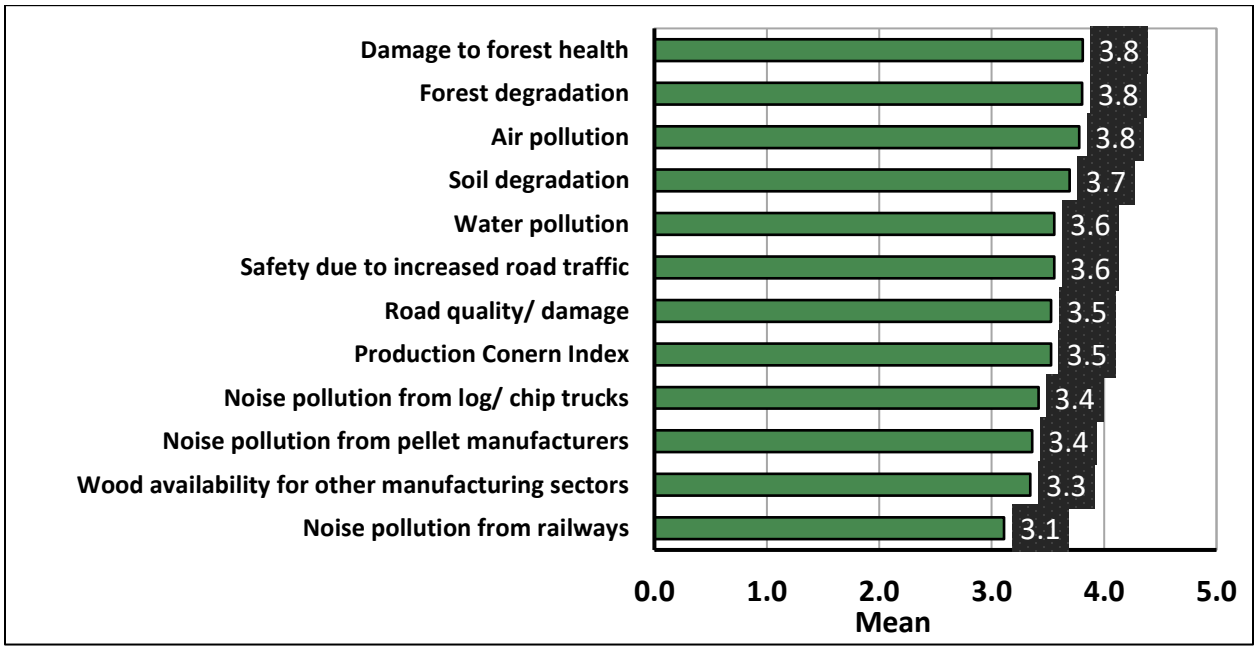

Figure 6.24. Social production concern issues of Atlantic Coast respondents (n=37) (1= Not concerned at all; 2= Not very concerned; 3= Neutral; 4= Somewhat concerned; 5= Very concerned)

6.3.5. Economic Perceptions of the Wood Pellet Manufacturing Industry

Of the 30.3% of respondents that owned forestland in their state of residence, 35% were Gulf Coast respondents and 65% were Atlantic Coast respondents. On average, respondents from the Atlantic Coast region owned 21.3 more acres of forestland compared to respondents from the Gulf Coast region. Using an independent sample two-tailed t-test it was determined that there was no statistically significant difference at $\alpha = 0.05$ significance level between Gulf Coast and Atlantic Coast respondents regarding the amount of forestland owned.

Regarding the types of financial support that respondents believe local, state, and federal governments should provide to the wood pellet manufacturing industry, state governments received the most responses. Overall, state government received the largest proportion of responses from both Gulf Coast (46.1%) and Atlantic Coast (44.1%) respondents across all items, indicating respondents from both areas thought government funding should primarily be provided by state governments.

6.3.6. Demographics

Table 6.16 reports the F-statistic and significance of on-way ANOVA test for the four continuous variables of population, age, education, and income as well as the value and asymptotic significance of Pearson's χ^2 test for the categorical variables of gender, ethnicity, and political affiliation.

Figure 6.25 presents the population of respondents' City/ Town. Using a one-way ANOVA test, it was determined that the difference in populations between Gulf Coast and Atlantic Coast respondents were not statistically significant at $\alpha = 0.05$ significance level. The results were roughly even.

Table 6.16. One-way ANOVA and χ^2 results for demographic variables

Demographic	F-Statistic	Significance (at α = 0.05)* (at α = 0.01)**	Demographic	Pearson's χ2 Value	Asymptotic Significance (at α = 0.05)* (at α = 0.01)**
Population of City/ Town	0.007	0.935	Gender	0.934	0.334
Age	0.177	0.675	Ethnicity	7.111	0.13
Level of Education	3.332	0.073	Political Affiliation	13.579	0.004
Level of Income	2.475	0.121			

a. 20% of cells have expected count <5

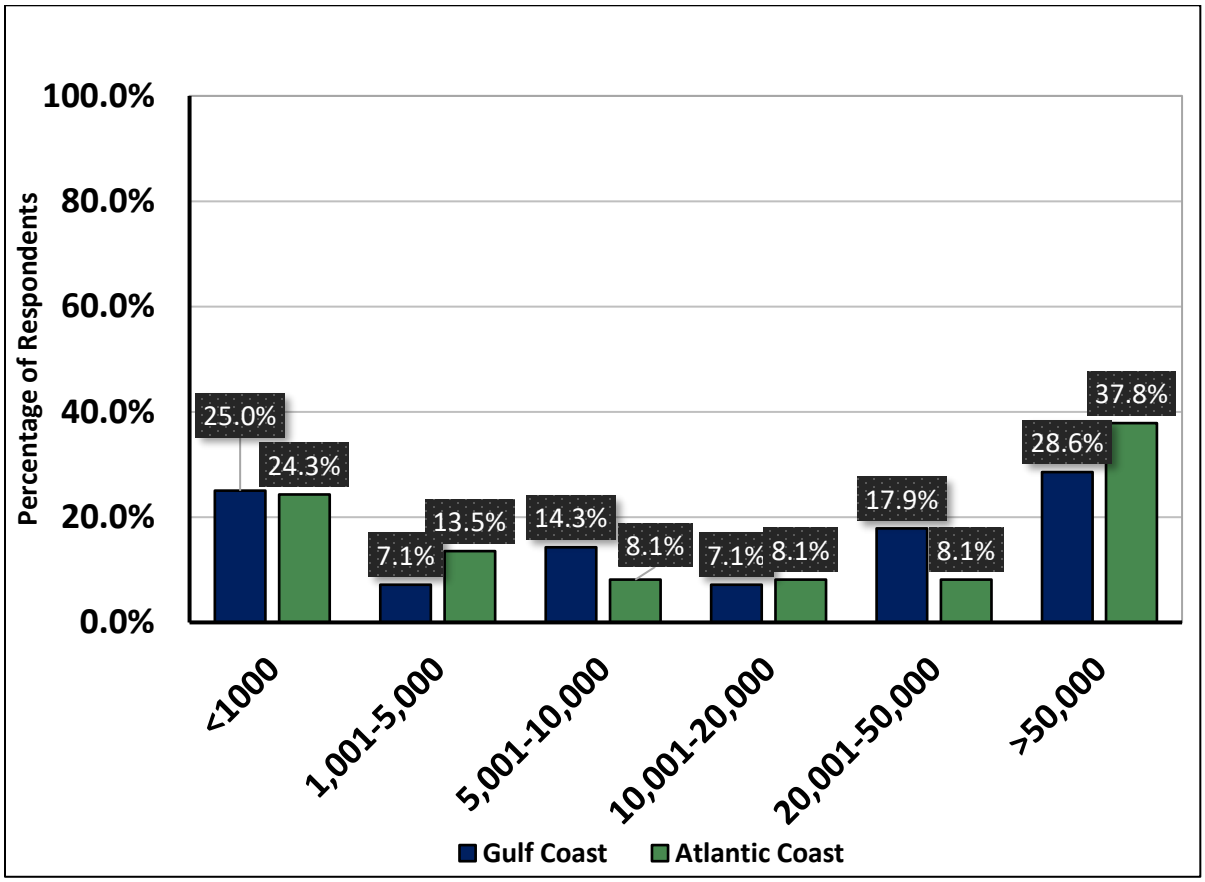

Figure 6.25. Population of respondent City/ Town (n=65)

A one-way ANOVA did not find any statistical significant difference between Gulf Coast and Atlantic Coast respondents and age at $\alpha = 0.05$ significance level. Age was roughly even among respondents (Figure 6.26).

Using Pearson's χ^2 test, no statistically significant association was found between gender and region at $\alpha = 0.05$ significance level. However, more females responded from the Gulf Coast at 60.7% compared to the nearly even gender of Atlantic Coast respondents (Figure 6.27). Similarly, using a one-way ANOVA, no statistically significant difference was found between the level of education of Gulf Coast and Atlantic Coast respondents at $\alpha = 0.05$ significance level. However, Atlantic Coast respondents were more educated as 70.2% had a college degree or higher compared to the 60.7% of Gulf Coast respondents (Figure 6.28).

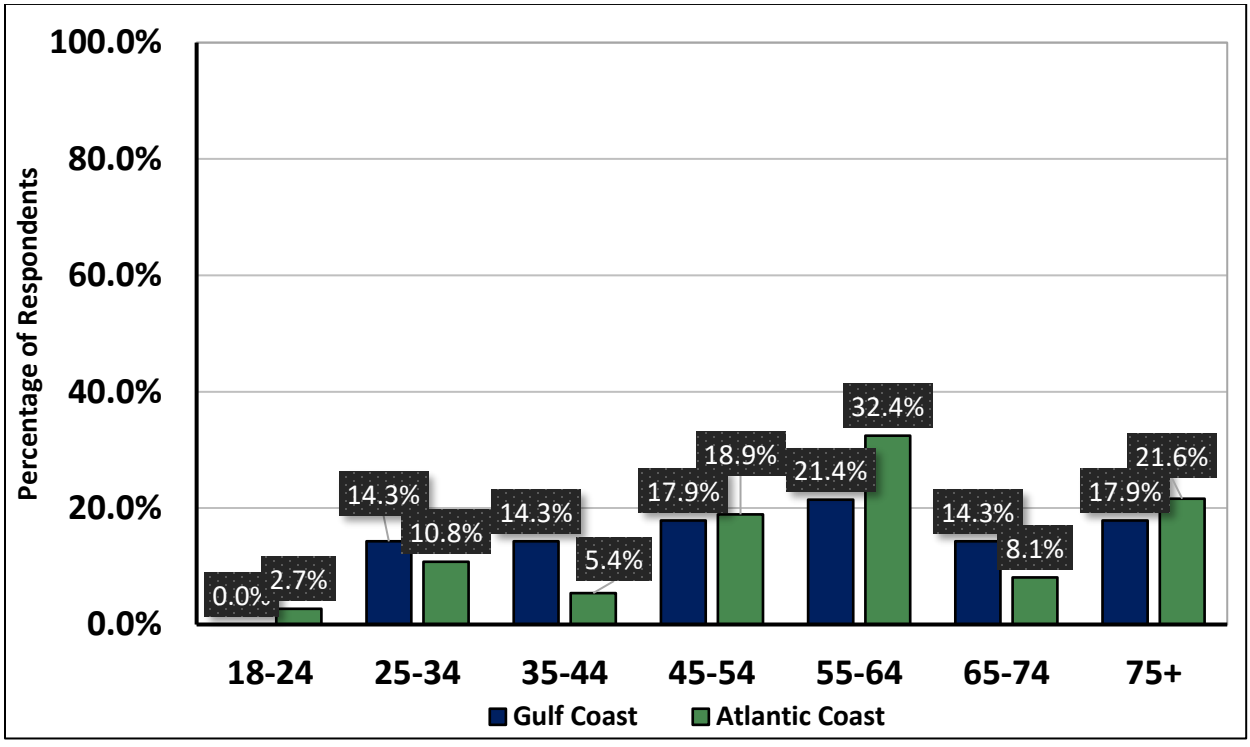

Figure 6.26. Age of respondents (n=65)

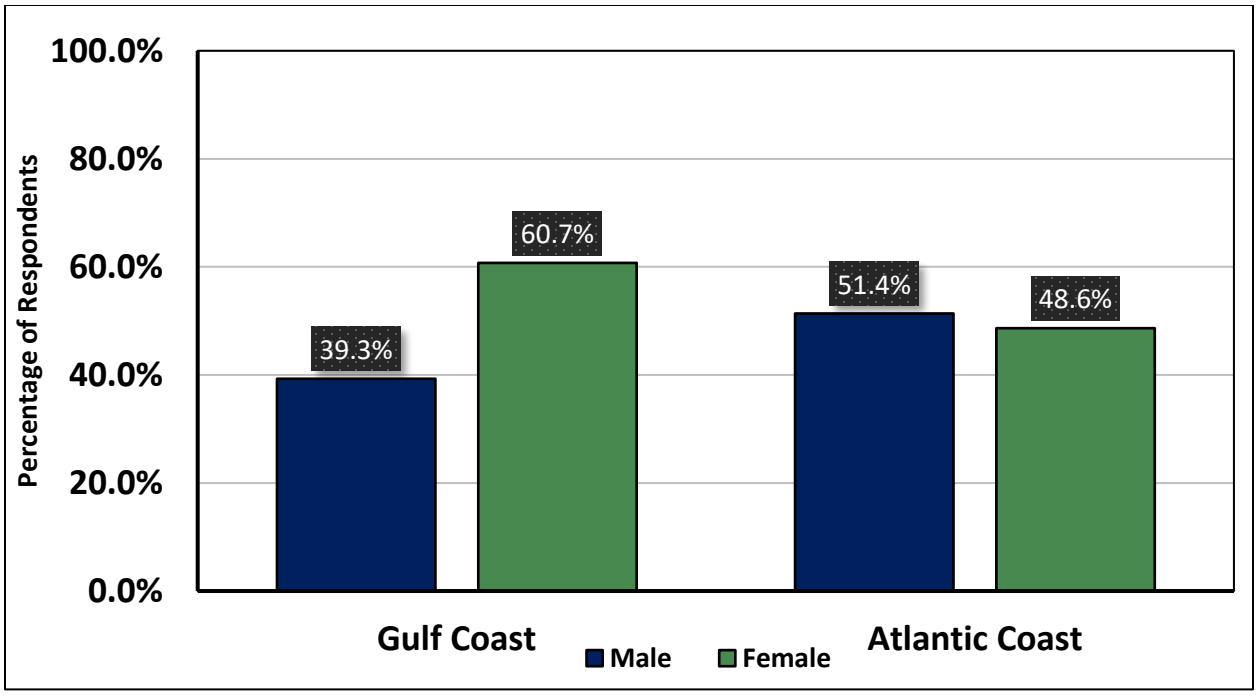

Figure 6.27. Gender of respondents (n=65)

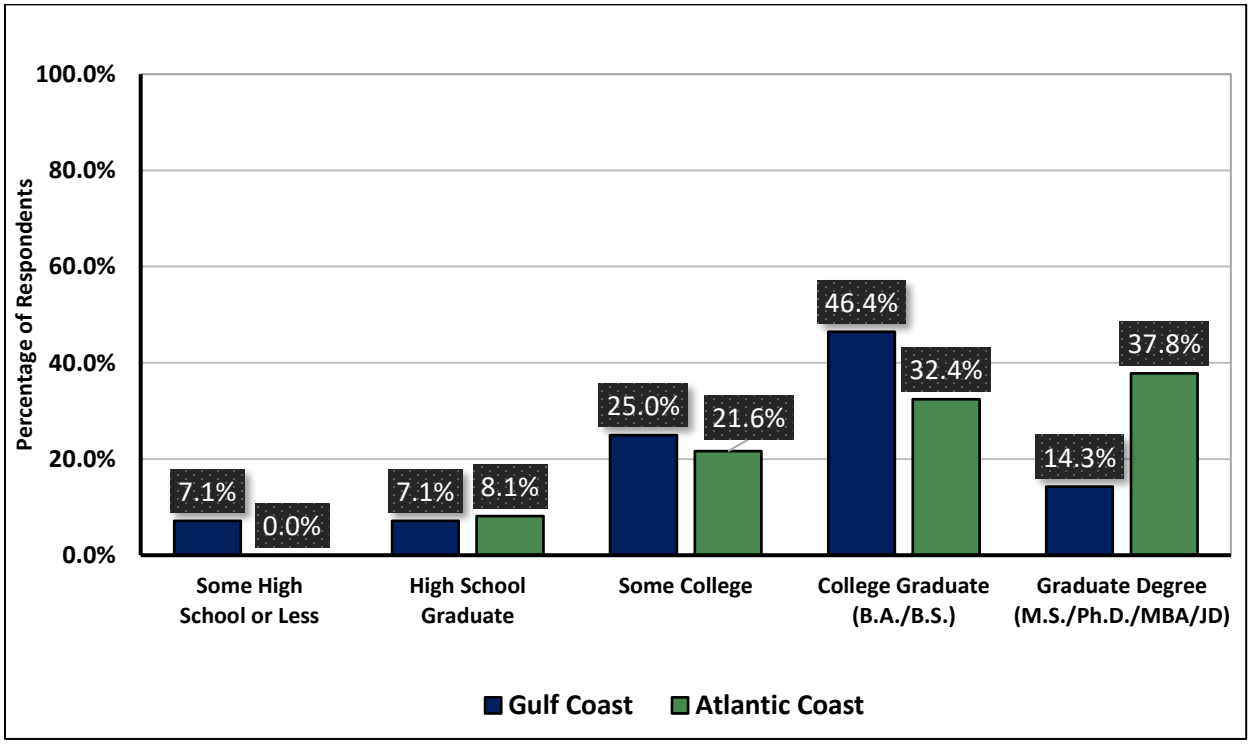

Figure 6.28. Respondent level of education (n=65)

No statistically significant association was found between ethnicity and region at $\alpha = 0.05$ significance level using Pearson's χ^2 test. Respondents from both regions were predominantly white (Figure 6.29). Similarly, using a one-way ANOVA, no statistically significant difference was found between the level of income of Gulf Coast and Atlantic Coast respondents at $\alpha = 0.05$ significance level. Nearly 41% of Gulf Coast respondents had a household income of less than $80,000 compared to the Atlantic Coast 27.9% (Figure 6.30). Comparable to level of education, this result was to be expected because of the association between education and income.

Lastly, a Pearson's χ^2 test revealed a statistically significant association between political affiliation and region at $\alpha = 0.05$ significance level. Atlantic Coast respondents were only 21.6% republican compared to the Gulf Coast 60.7% (Figure 6.31). Over 48% of Atlantic Coast respondents reported they were democrats compared to the 14.3% of Gulf Coast respondents.

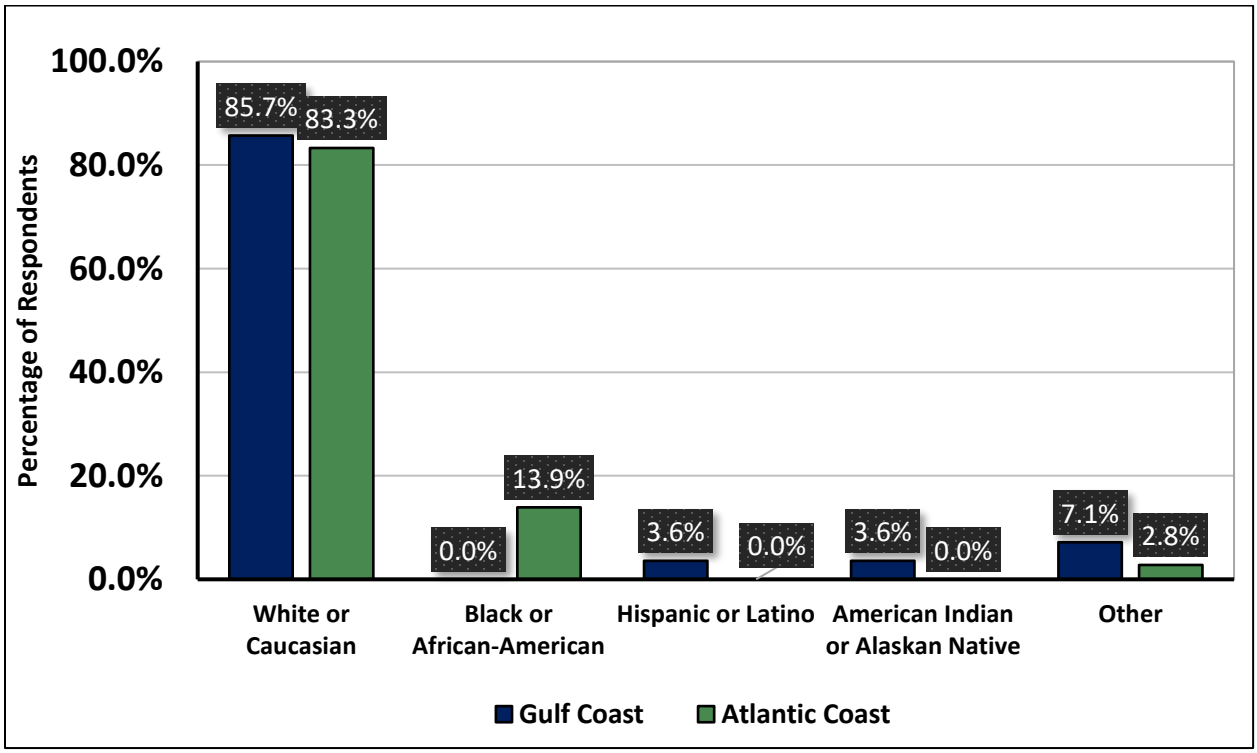

Figure 6.29. Ethnicity of respondents (n=64)

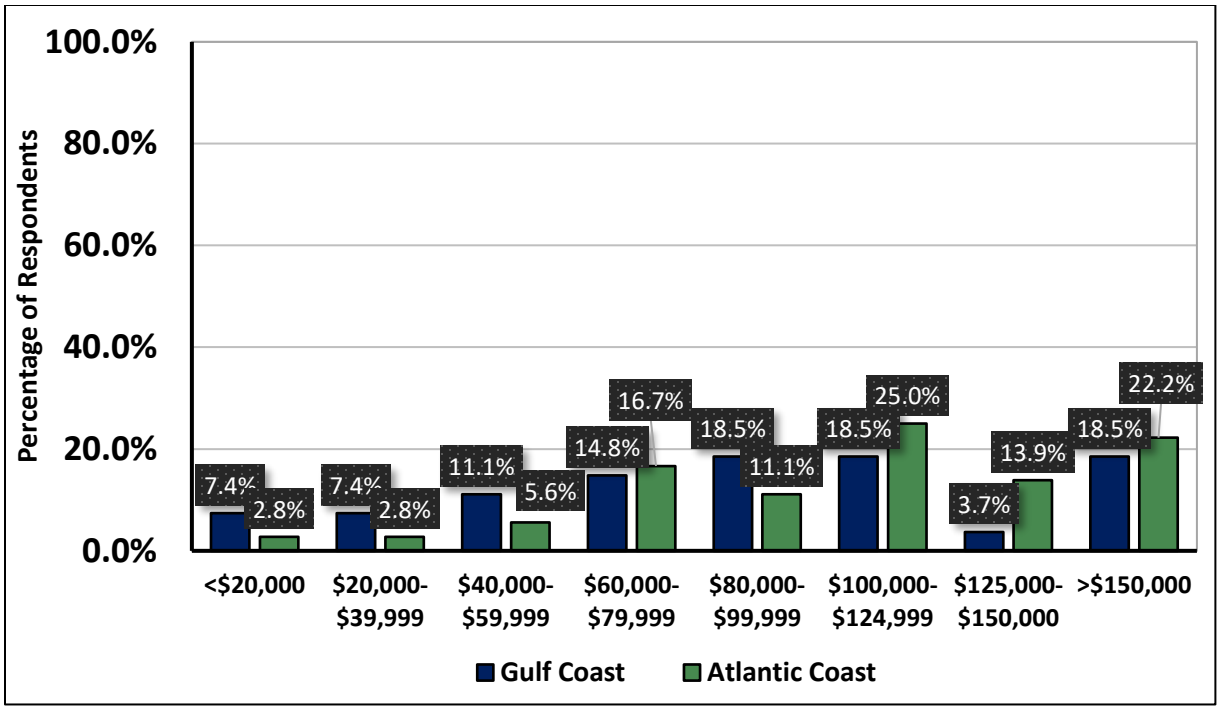

Figure 6.30. Respondent level of income (n=63)

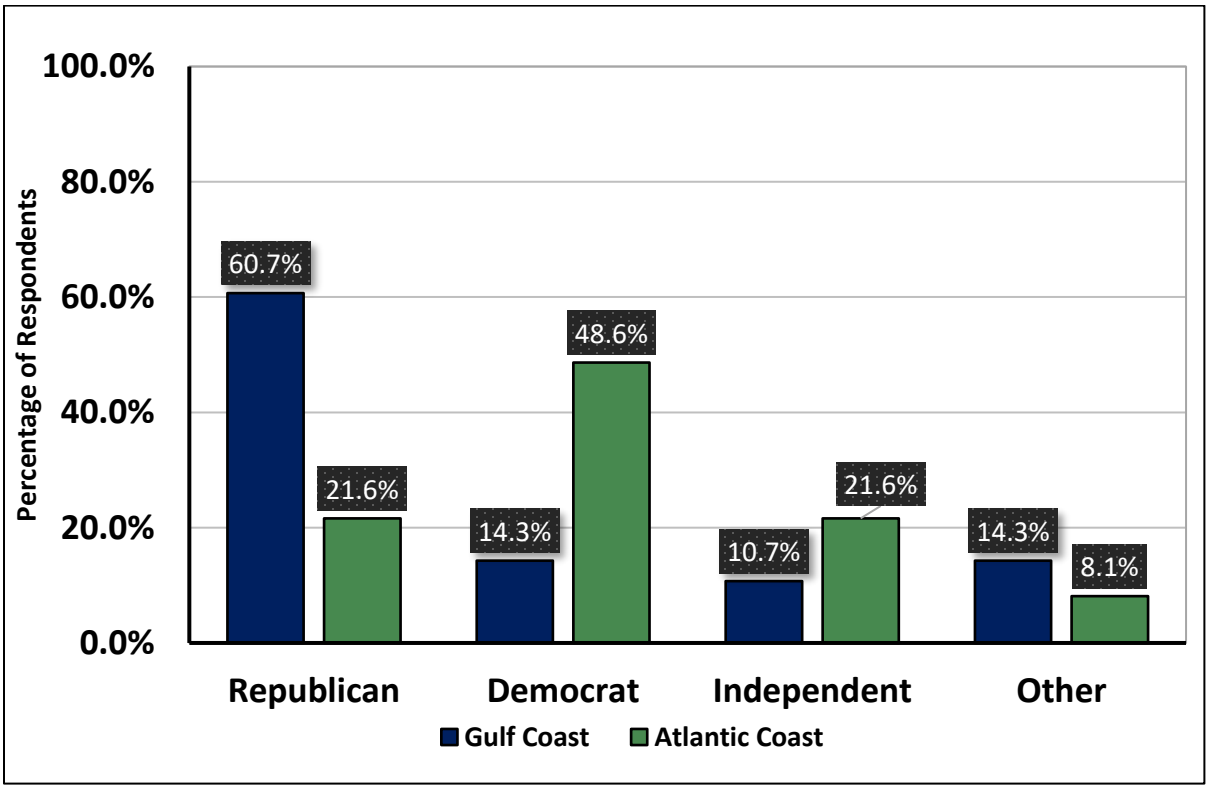

Figure 6.31. Political affiliation of respondents (n=65)

CHAPTER 7. DISCUSSION AND CONCLUSION

7.1. Resident Perceptions of the Wood Pellet Manufacturing Industry

7.1.1. Introduction

This study was conducted using a web-based survey pertaining to environmental, social, and economic perceptions of the wood pellet manufacturing industry in the US South. The survey sought to determine the attitudes, awareness, behaviors, perceptions, and underlying issues of the industry from perceptions of the general public, specifically those of residents living near or in communities where pellet mills are located and residents within the two largest MSAs of each state that hosted the selected mills. The collection of these perceptions allowed for two comparisons to be made between residents based on contrasts in population and geographic location: 1. Residents in rural mill communities and residents in urban MSAs; 2. Residents in the Gulf Coast and residents in the Atlantic Coast. This thesis better frames issues from the perspectives of Southern residents and begins to define a relationship between the wood pellet manufacturing industry and the general public.

7.1.2. Urban/ Rural Perceptions

The survey revealed that rural respondents were more aware of the wood pellet manufacturing industry compared to urban respondents. Overall, the survey revealed that rural respondents more strongly approved of the industry's environmental, social, and economic impacts and contributions toward local communities. This is not to say that people who live in rural areas are not concerned with negative environmental and social impacts, but residents who live in urban areas have a higher concern for the environment and stronger economies compared to residents that live in rural areas. Rural respondents reported only air quality to be negatively impacted while urban respondents reported all environmental items of Table 6.6 to be negatively

impacted. Similarly, rural respondents were overall less concerned with social production concern issues compared to urban respondents. The economic benefits of the wood pellet manufacturing industry for rural areas seemed to outweigh the environmental and social impacts. Rural respondents generally held the wood pellet manufacturing industry in higher regard compared to urban respondents.

7.1.3. Gulf Coast and Atlantic Coast Perceptions

The survey also revealed that Gulf Coast respondents were more aware of the wood pellet manufacturing industry compared to Atlantic Coast respondents. Overall, the survey revealed that Gulf Coast respondents more strongly approved of the industry's environmental, social, and economic impacts and contributions toward local communities. Gulf Coast respondents reported only wildlife habitat to be negatively impacted while Atlantic Coast respondents reported all environmental items of Table 6.14 to be negatively impacted. Similarly, Gulf Coast respondents were overall less concerned with social production concern issues compared to Atlantic Coast respondents. Gulf Coast respondents generally held the wood pellet manufacturing industry in higher regard compared to Atlantic Coast respondents.

7.2. Implications and Future Research

The general public plays a crucial role in the outcome of an extractive project. The human, social, and financial capital presented by the general public are of significant interest to companies seeking long-term success. Transparent and responsible use of natural resources are expected by local communities in return for these sources of capital. In the context of the wood pellet manufacturing industry, initiatives are being developed by companies to better communicate environmental efforts though community outreach programs. Regarding the research on business-community relationships of the wood pellet manufacturing industry to

assist these initiatives, there is a significant gap in the knowledge-base. Overall, no prior primary empirical research has been conducted that examines the environmental, social, and economic perceptions of residents as they relate to the industry.

The findings of this research are a foundation for Southern wood pellet manufacturing companies to develop community engagement programs amongst the strategies to remain socially responsible and transparent with the public. The revelation of environmental, social, and economic perceptions of this emerging industry allows companies in the South to align their goals to that of resident public perception and examine potential future impacts based on respondent perceptions. The research findings are also useful to local and state governments for formulating new policies to promote sustainable industrial practices in the South. In the future, public policy is likely to place increasing importance on environmentally responsible business practices that affect the overall health of the general public, sustainability of natural resource extraction, and mitigation of climate change.

Going forward, future research should investigate perceptions from a broader range of stakeholders involved with the wood pellet manufacturing industry. The collection of perceptions from stakeholders such as forest landowners, forest supply chain employees, and government entities would further depict and explain the perceptions and overall attitudes toward the wood pellet manufacturing industry.

APPENDIX A. SURVEY INSTRUMENT

RESIDENTIAL PERCEPTIONS OF THE WOOD PELLET MANUFACTURING INDUSTRY

Section I: Wood Pellet Manufacturing Industry Awareness

1. How aware are you of the wood pellet manufacturing industry in general?

Not at all aware	Not very aware	Neither aware nor unaware	Somewhat aware	Very aware
○	○	○	○	○

2. Are you aware of any wood pellet manufacturers?

__No

__Yes

3. Please select the wood pellet manufacturers that you are aware of from the following list: (Please select all that apply)

__Drax Biomass

__Pro-Pellet

__Mohegan Renewable Energy

__Enviva

__Europellet

__Georgia-Biomass

__Nature's Earth Pellet Energy

__Pellet Source Energy

__Nextgen Renewable Fuels

__Environ-Fuel

__Highland Pellets

__Equustock

__Fram Renewable Fuels

__None of these

4. Please assign your level of agreement with the following statements regarding the wood pellet manufacturing industry.

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
I am aware of wood pellet manufacturers in my state.	1	2	3	4	5
I am very knowledgeable about the wood pellet manufacturing industry.	1	2	3	4	5

5. How did you hear about or get information on the pellet manufacturing industry? (Please select all that apply)

__Internet news services (e.g. CNN, FOX) __Social media (e.g. Twitter, Facebook)

__Local newspaper __National newspaper

__Friend __Popular Magazine (e.g. People, Time)

__Family __Other _____(Please specify)_____

6. What do you think wood pellets are made from? (Please select all that apply)

__Whole logs used for lumber __Logs unsuited for lumber production

__Clear-cut forests __Forest thinnings

__Softwoods (e.g. Pine) __Hardwoods (e.g. Oak & Hickory)

__Sawmill residuals (e.g. Sawdust) __Forest residuals (e.g. limbs & treetops)

__Don't Know

7. What do you think wood pellets are used for? (Please select all that apply)

__Private electricity generation __Exports

__Industrial electricity generation __Cooking (e.g. BBQ)

__Home heating __Don't know

__Mulch

Section II: General Perceptions

8. Please select your level of agreement with the following statements (Please select one for each)

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
Humans have the right to modify the environment to suit their needs.	1	2	3	4	5
Human economic needs are more important than protecting the environment.	1	2	3	4	5
When humans interfere with the environment it often produces disastrous consequences.	1	2	3	4	5
The balance of nature is strong enough to cope with the impacts of industrialization.	1	2	3	4	5
Humans are accelerating the rate of global warming.	1	2	3	4	5
Climate change caused by humans has been greatly exaggerated.	1	2	3	4	5
Humans were meant to rule over the rest of nature.	1	2	3	4	5
Humans will eventually learn enough about global warming to be able to control it.	1	2	3	4	5
If things continue on their present course, we will soon experience a major climate change catastrophe.	1	2	3	4	5
Climate change is a naturally occurring phenomena, not caused by humans.	1	2	3	4	5

9. Which types of ownership do you believe forests in the US should be harvested from for commercial products? (Please select all that apply)

__Forest Service Land (Federal)

__Bureau of Land Management Land (Federal)

__US National Parks (Federal)

__Designated Wilderness Areas (Federal)

__Small Family Timberland (Private)

__Large Family Timberland (Private)

__Small Corporate Timberland (Private)

__Large Corporate Timberland (Private)

__State Owned Land

__None Of These

10. Please indicate your level of agreement with the following statements: (Please select one for each)

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
It is important to me that the companies in my community do not harm the environment.	1	2	3	4	5
I/my family recycles materials such as glass, plastic, and paper.	1	2	3	4	5
My community has a recycling program in place for materials such as glass, plastic, and paper.	1	2	3	4	5
I am generally concerned about the natural resources in my community such as forest, air, and water.	1	2	3	4	5
I am willing to be inconvenienced in order to participate in recycling that is environmentally friendly in my community.	1	2	3	4	5

11. Please indicate your level of agreement with the following statements: (Please select one for each)

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
Job creation is important to my community.	1	2	3	4	5
My community has a strong economy.	1	2	3	4	5
A strong economy is important to my community.	1	2	3	4	5
Local government should provide financial support to develop/ maintain businesses in my community.	1	2	3	4	5
State government should provide financial support to develop/ maintain businesses in my community.	1	2	3	4	5
The Federal Government should provide financial support to develop/ maintain businesses in my community.	1	2	3	4	5
Industry should stand on its own without government support/ intervention.	1	2	3	4	5

12. Generally, what is your level of agreement regarding the need for the following sources of energy to be a priority in the United States?

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
Solar	1	2	3	4	5
Hydro	1	2	3	4	5
Wood Biomass	1	2	3	4	5
Agricultural Biomass	1	2	3	4	5
Geothermal	1	2	3	4	5
Wind	1	2	3	4	5
Coal	1	2	3	4	5
Natural Gas	1	2	3	4	5
Oil	1	2	3	4	5

13. In my opinion, wood pellets are a viable energy alternative to fossil fuels.

Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
○	○	○	○	○

14. In general, what is your overall opinion of using wood pellets for energy?

Extremely Negative	Somewhat Negative	Neutral	Somewhat Positive	Extremely Positive
○	○	○	○	○

Section III: Environmental Perceptions of the Wood Pellet Manufacturing Industry

15. Please indicate your level of agreement with the following statements regarding the wood pellet manufacturing industry. (Please select one for each)

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
I trust the wood pellet manufacturing industry to act in the best interest of the environment.	1	2	3	4	5
I think the wood pellet manufacturing industry utilizes appropriate forest management practices.	1	2	3	4	5
Currently, the wood pellet manufacturing industry is effective in its efforts to help protect the environment.	1	2	3	4	5
Wood pellets are an environmentally superior alternative method of energy generation relative to fossil fuels.	1	2	3	4	5
Harvesting trees to manufacture wood pellets is harmful to the environment.	1	2	3	4	5

16. Please indicate your opinion toward the following statements regarding the wood pellet manufacturing industry. (Please select one for each)

Overall, I believe the wood pellet manufacturing industry impacts on the following are…...

	Extremely Negative	Somewhat Negative	Neutral	Somewhat Positive	Extremely Positive
wildlife habitat.	1	2	3	4	5
water quality.	1	2	3	4	5
air quality.	1	2	3	4	5
soil quality.	1	2	3	4	5
sustainable forests.	1	2	3	4	5
forest-based recreation.	1	2	3	4	5

Section IV: Social Perceptions of the Wood Pellet Manufacturing Industry

17. Please indicate your level of agreement with the following statements regarding the wood pellet manufacturing industry. (Please select one for each)

The wood pellet manufacturing industry…….

	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
is concerned about the needs of communities.	1	2	3	4	5
contributes to community economic health.	1	2	3	4	5
contributes to community activities and services.	1	2	3	4	5
is a good industry to work for.	1	2	3	4	5
creates quality jobs.	1	2	3	4	5
is a superior industry for communities.	1	2	3	4	5

18. Please indicate your level of concern for the following issues associated with converting wood to pellets for energy production. (From the forest to the manufacturing process)

	Not concerned at all	Not very concerned	Neutral	Somewhat concerned	Very concerned
Wood availability for other manufacturing sectors	1	2	3	4	5
Damage to forest health	1	2	3	4	5
Air pollution	1	2	3	4	5
Safety due to increased road traffic	1	2	3	4	5
Noise pollution from pellet manufacturers	1	2	3	4	5
Noise pollution from log/ chip trucks	1	2	3	4	5
Noise pollution from railways	1	2	3	4	5
Water pollution	1	2	3	4	5
Soil degradation	1	2	3	4	5
Forest degradation	1	2	3	4	5
Road quality/ damage	1	2	3	4	5

Section V: Economic Perceptions of the Wood Pellet Manufacturing Industry

19. Do you own forestland in the state that you live in?

__No

__Yes

20. Approximately how many acres of forestland did you own in your state in 2018?_____

21. Have you **EVER** sold woody biomass from your land to the wood pellet manufacturing industry?

__No

__Yes

22. Did you sell woody biomass to the wood pellet manufacturing industry in **2018**?

__No

__Yes

23. Roughly, please ***estimate*** the percentage of the following wood materials that you sold to the wood pellet manufacturing industry **in 2018**. (Total must equal 100%)

Pine Pulpwood

(9” or less DBH)_____

Hardwood Pulpwood

(11” or less DBH)_____

Pine Saw-timber

(10” or more DBH)_____

Hardwood Saw-timber

(12” or more DBH)_____

Pre-Commercial

Thinnings_____

Post-Harvest Residuals

(Slash/ Tops/ Branches)_____

Whole Trees SPECIFICALLY

thinned for the pellet customers

(i.e. energy thinnings)_____

Other_____

24. If your answer to question #24 included the “other” option, please specify what that was below:

_____

25. Please **ESTIMATE** how many tons of woody biomass of **ALL TYPES** you sold tgo the wood pellet manufacturing industry in **2018**.

_____

26. Roughly, how many different pellet manufacturer companies purchased woody biomass from you in **2018**?

_____

27. Are you employed by the wood pellet manufacturing industry?

__No

__Yes

28. In what capacity or capacities? _____(Job Title (s))_____

29. Are any other family members at your place of residence employed by the wood pellet manufacturing industry?

__No

__Yes

30. In what capacity or capacities? _____(Job Title (s))_____

31. Are you employed by an industry in the wood pellet supply chain, not including wood pellet manufacturers?

__No

__Yes

__Don't know

32. Which industry or job are you employed by within the wood pellet supply chain? (Please select one)

__Logger __Forester (woods worker)

__Chipper __Consulting Forester

__Trucking __International Exporter

__Rail __Sawmill

__Broker __Port Employee

__Consultant __Other_____(Please specify)_____

33. Please indicate the types of financial support local, state, and/ or federal governments should provide to the wood pellet manufacturing industry. (Please select one for each type of support)

	Local	State	Federal
Property tax incentives	__	__	__
Sales tax incentives	__	__	__
Investment tax credits	__	__	__
Job creation incentives	__	__	__
Development grants	__	__	__

Section VI. Demographics

Please tell us a little about yourself. Remember, <u>your answers are completely confidential</u>

34. What is the population of your city/ town?

__Less than 1000

__1001-5000

__5001-10,000

__10,001-20,000

__20,001- 50,000

__More than 50,000

35. What is your age?

__18-24 __45-54

__25-34 __55-64

__35-44 __65-74

__75+

36. What is your gender?

__Male

__Female

37. What is your level of education? (Please fill in the highest level reached)

__Some High school or less

__High School Graduate

__Some College

__College Graduate (B.A./ B.S.)

__Graduate Degree (M.S./ Ph.D., MBA, JD)

38. What is your ethnic group?

__White or Caucasian __Hispanic or Latino

__Black or African-American __American Indian or Alaskan Native

__Asian or Asian American __Other

__Native Hawaiian or Other Pacific Islander

39. What is your best estimate of the total combined income of all members of the owner's household in **2018**? (Please include NET income from businesses, farming, and rentals, money from jobs, pensions, dividends, interest, social security, unemployment, welfare, and workman's compensation.) **(**Please fill in only one)

__Less than $20,000 __$80,000-$99,999

__$20,000-$39,999 __$100,000-$124,999

__$40,000-$59,999 __$125,000-$150,000

__$60,000-$79,999 __Over $150,000

40. Please indicate your political party affiliation.

__Republican __Independent

__Democrat __Other

APPENDIX B. OVERALL SURVEY RESULTS

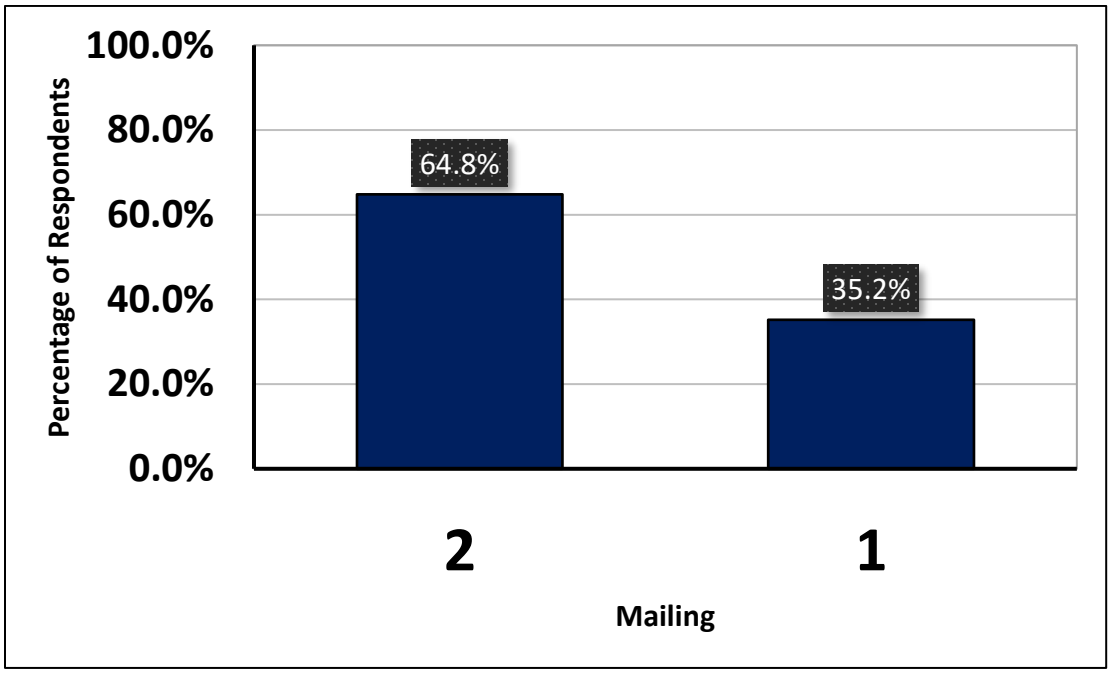

Figure B.1. Responses by mailing (n=122)

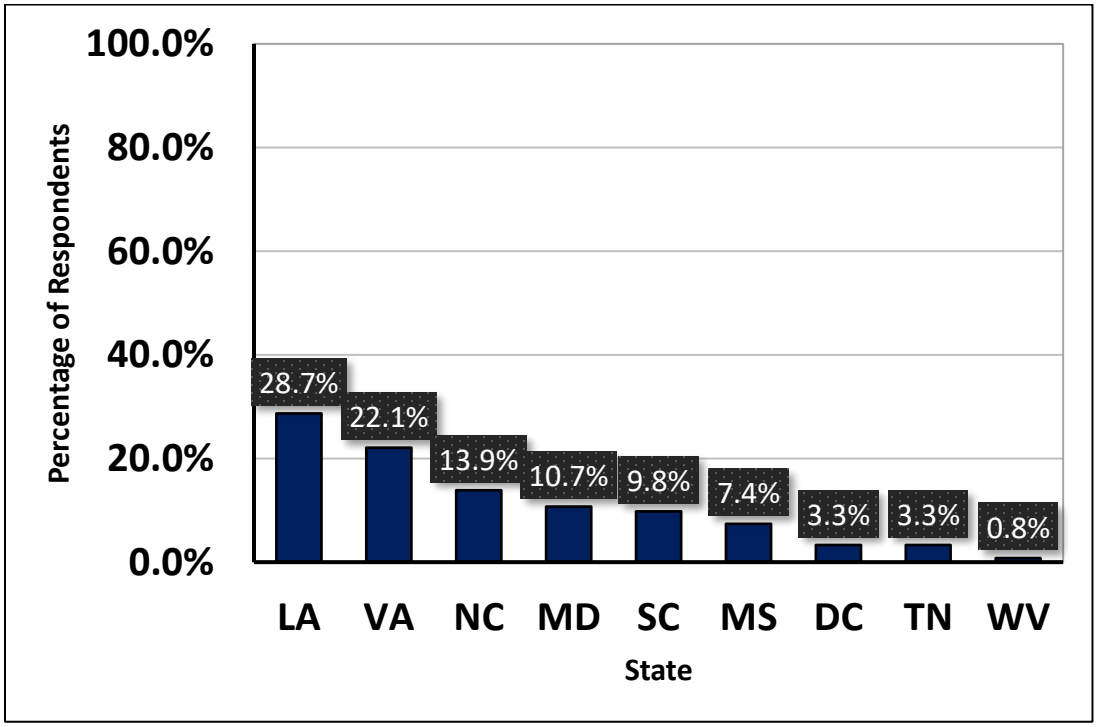

Figure B.2. Respondents by state (n=122)

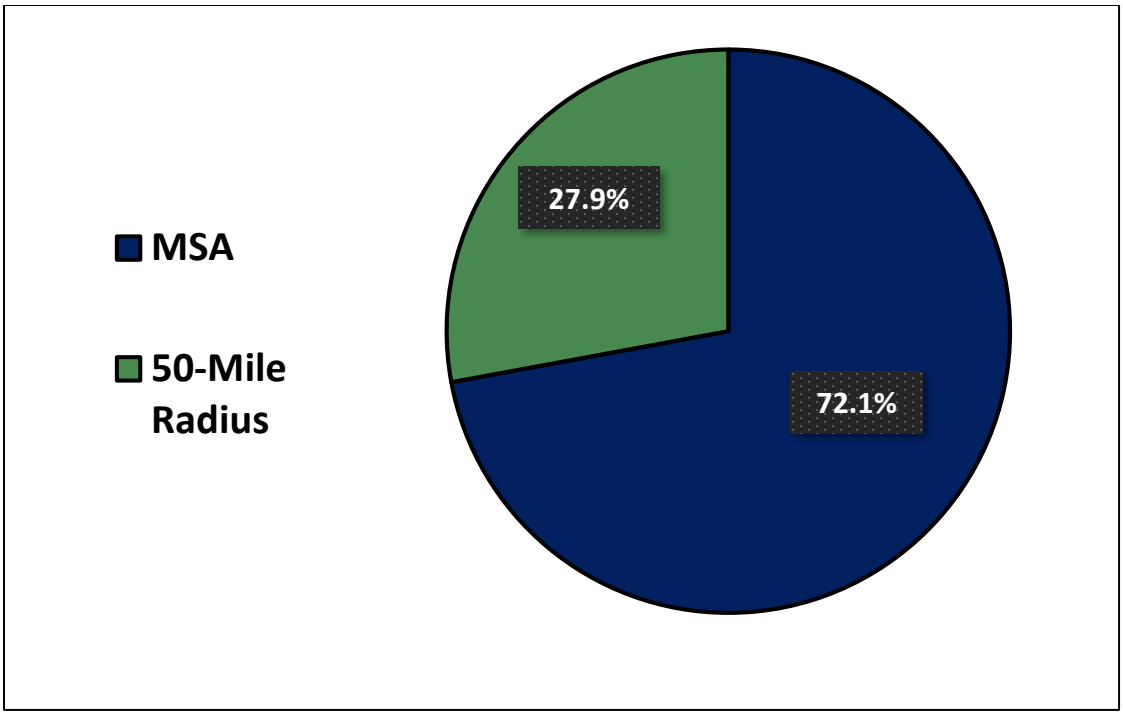

Figure B.3. Percentage of respondents by MSA and 50-mile mill radius (n=122)

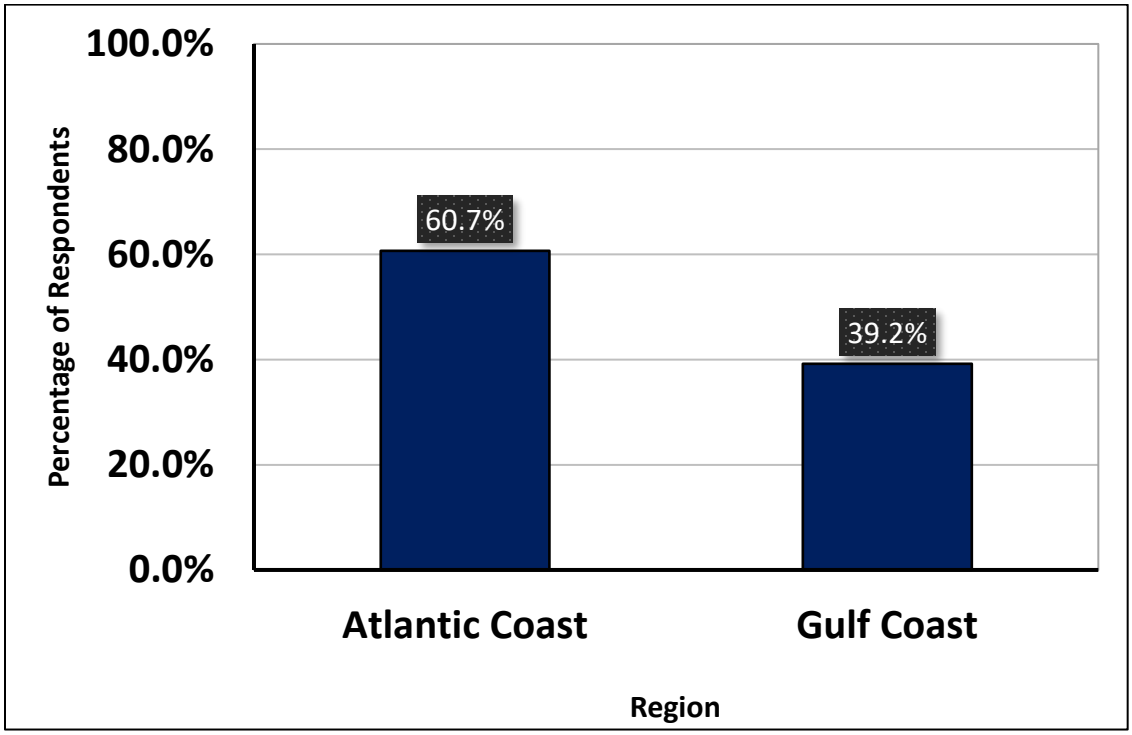

Figure B.4. Percentage of respondents by region (n=122)

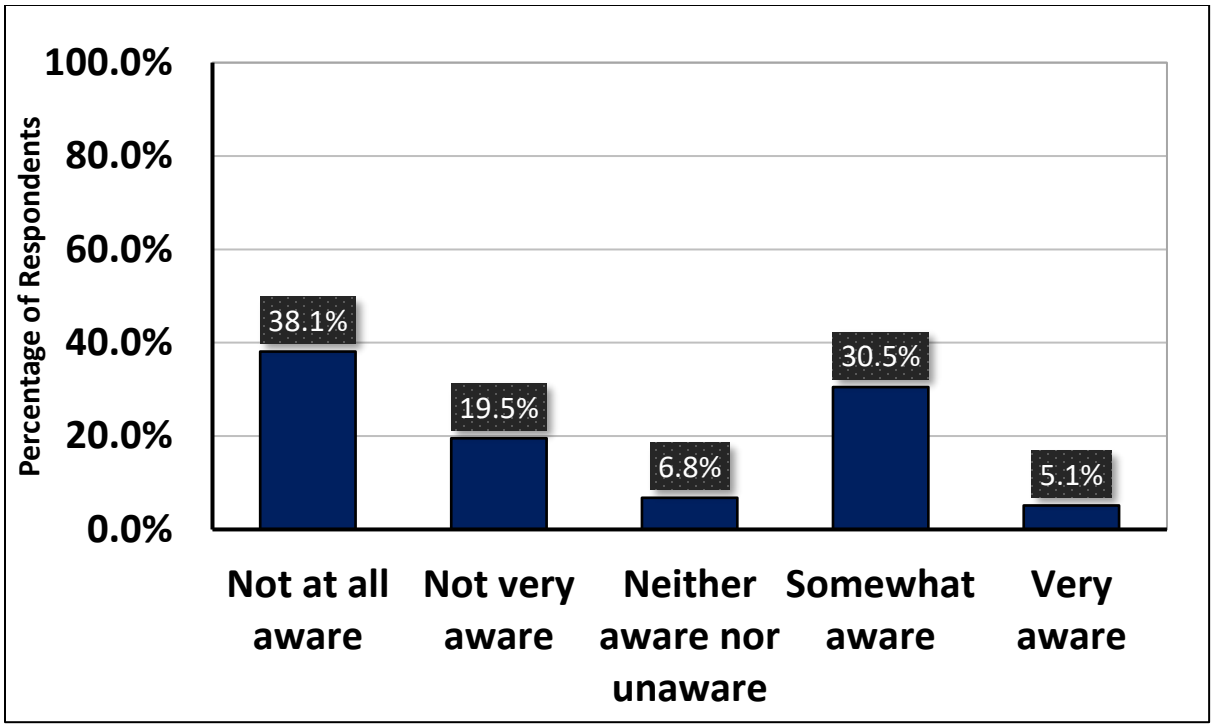

Figure B.5. How aware are you of the wood pellet manufacturing industry in general? (n=118)

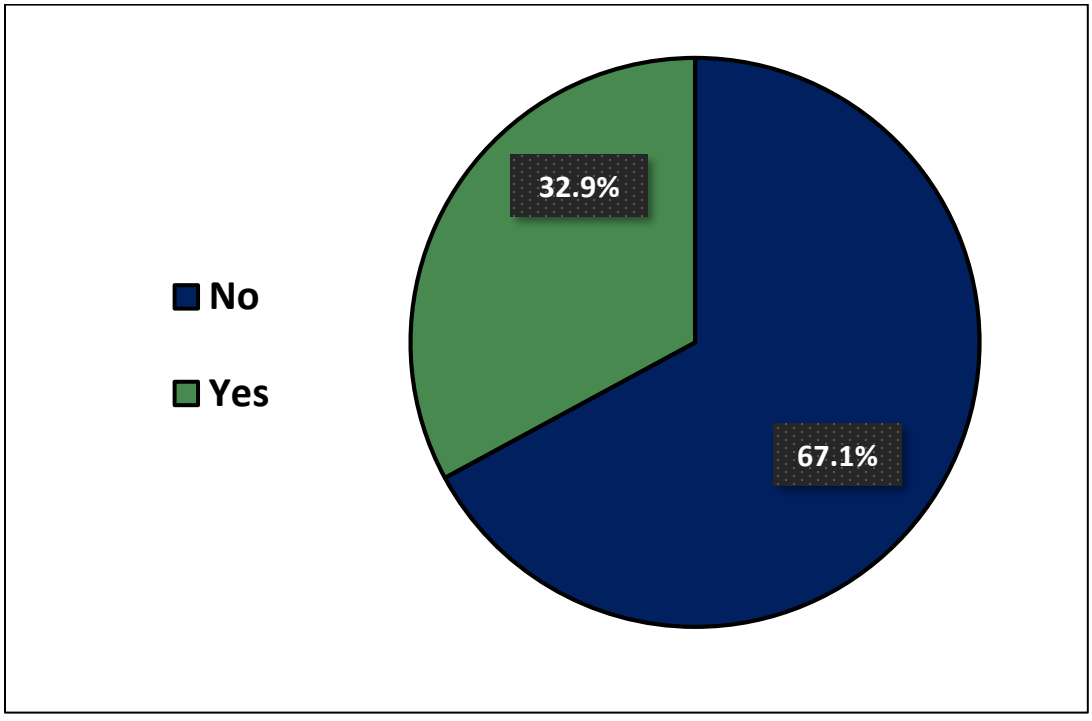

Figure B.6. Are you aware of any wood pellet manufacturers? (n=73)

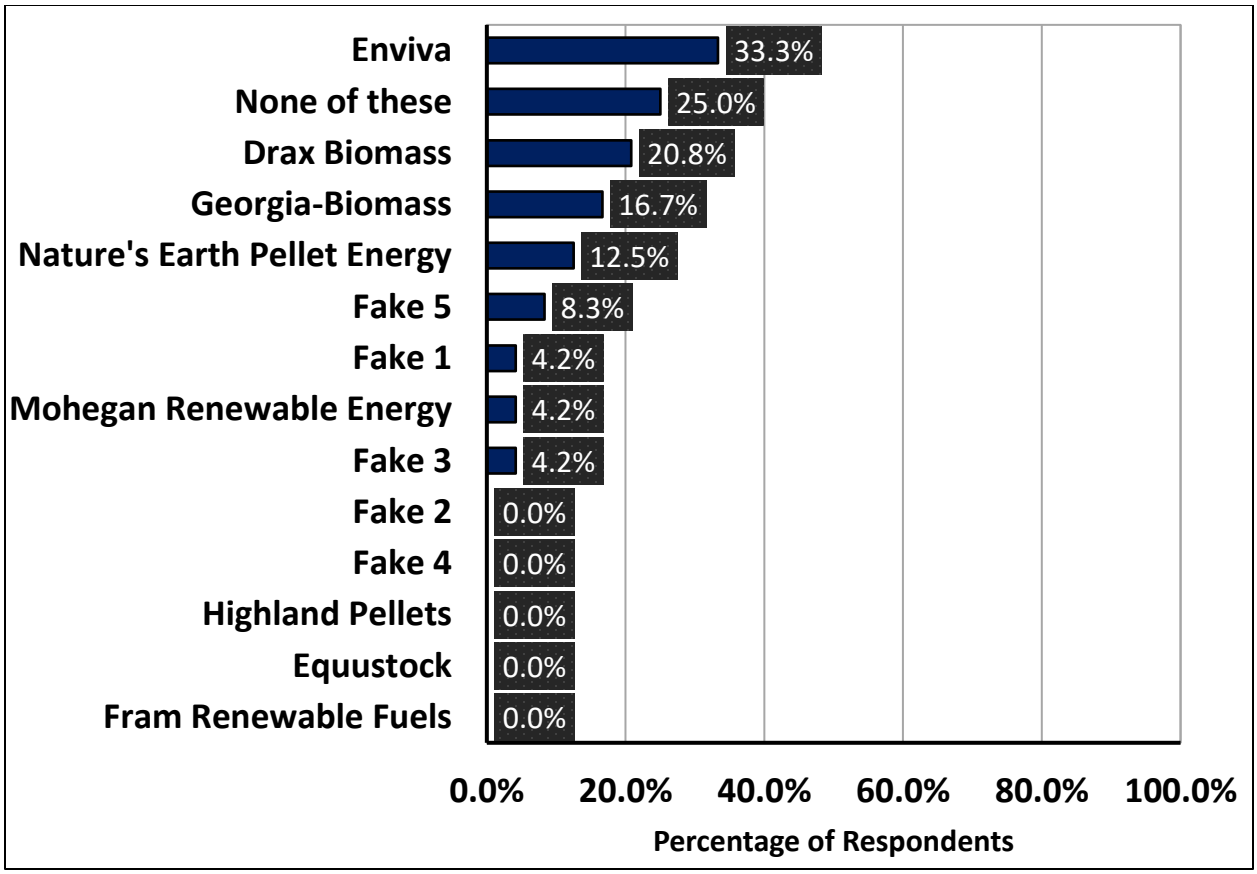

Figure B.7. Respondent awareness of listed wood pellet manufacturers (n=24)(Multiple responses possible)

Table B.1. Please assign your level of agreement with the following statements regarding the wood pellet manufacturing industry. (1=Strongly Disagree; 2= Somewhat Disagree; 3= Neutral; 4= Somewhat Agree; 5= Strongly Agree)

Item	n	Mean
I am aware of wood pellet manufacturers in my state.	68	2.5
I am very knowledgeable about the wood pellet manufacturing industry.	67	2.0

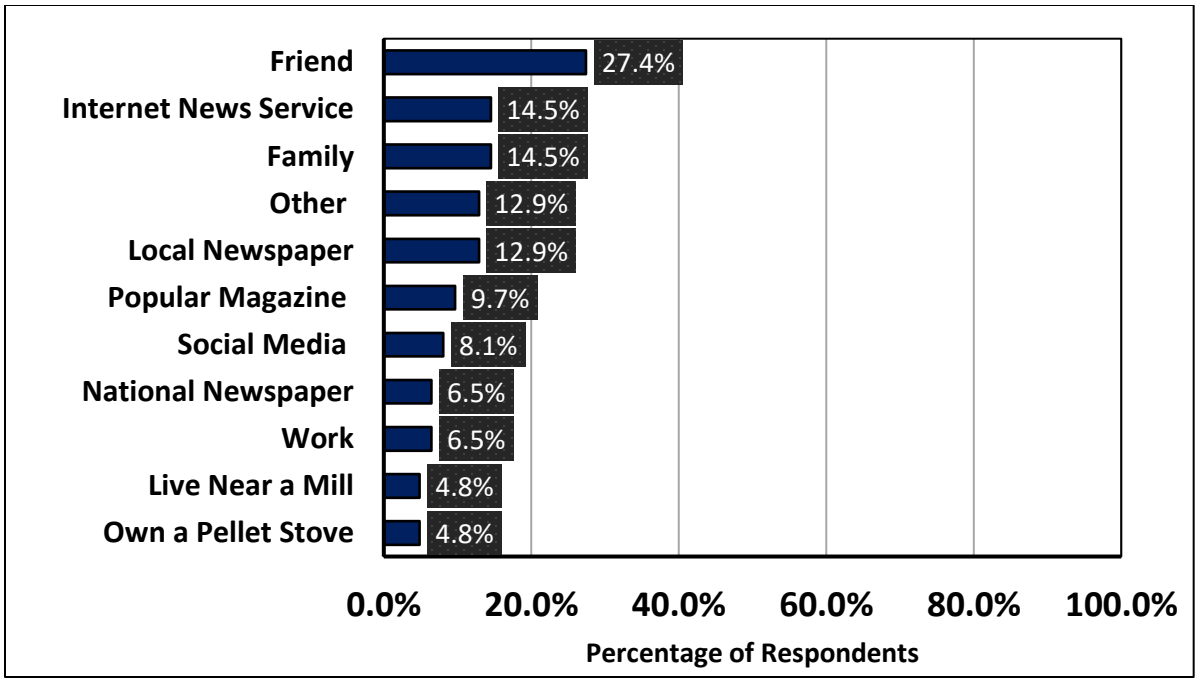

Figure B.8. How did you hear about or get information on the pellet manufacturing industry? (n=62)(Multiple responses possible)

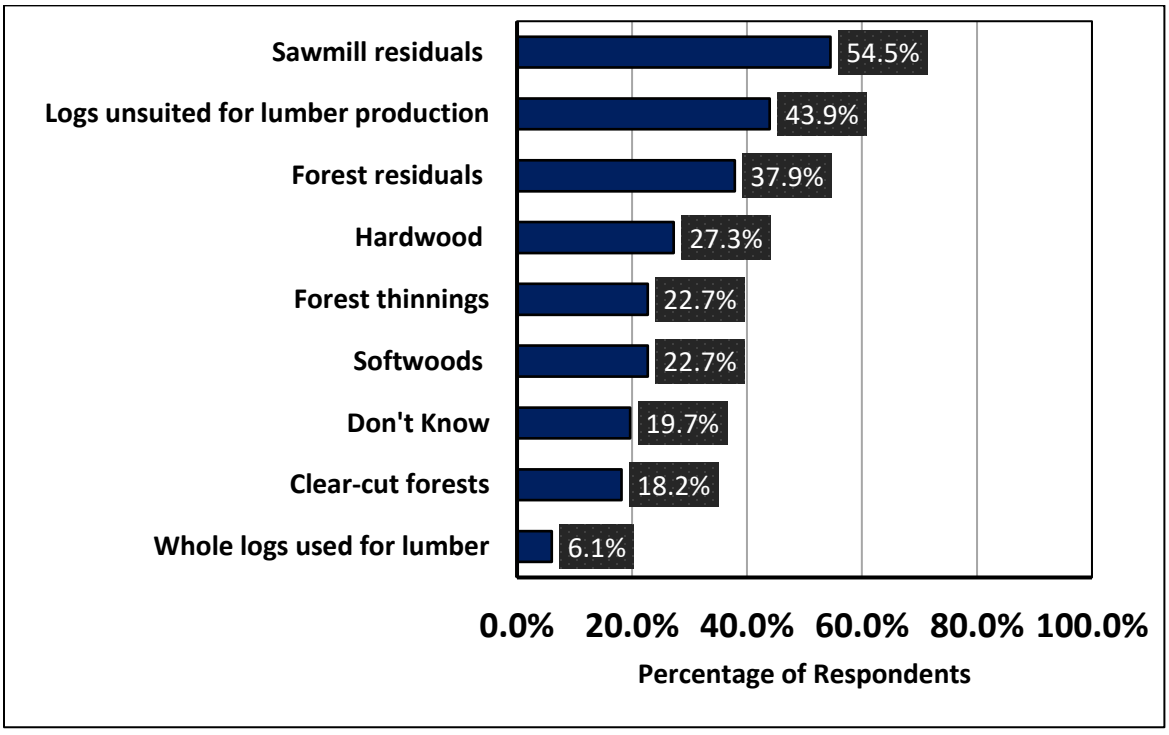

Figure B.9. What do you think wood pellets are made from? (n=66)(Multiple responses possible)

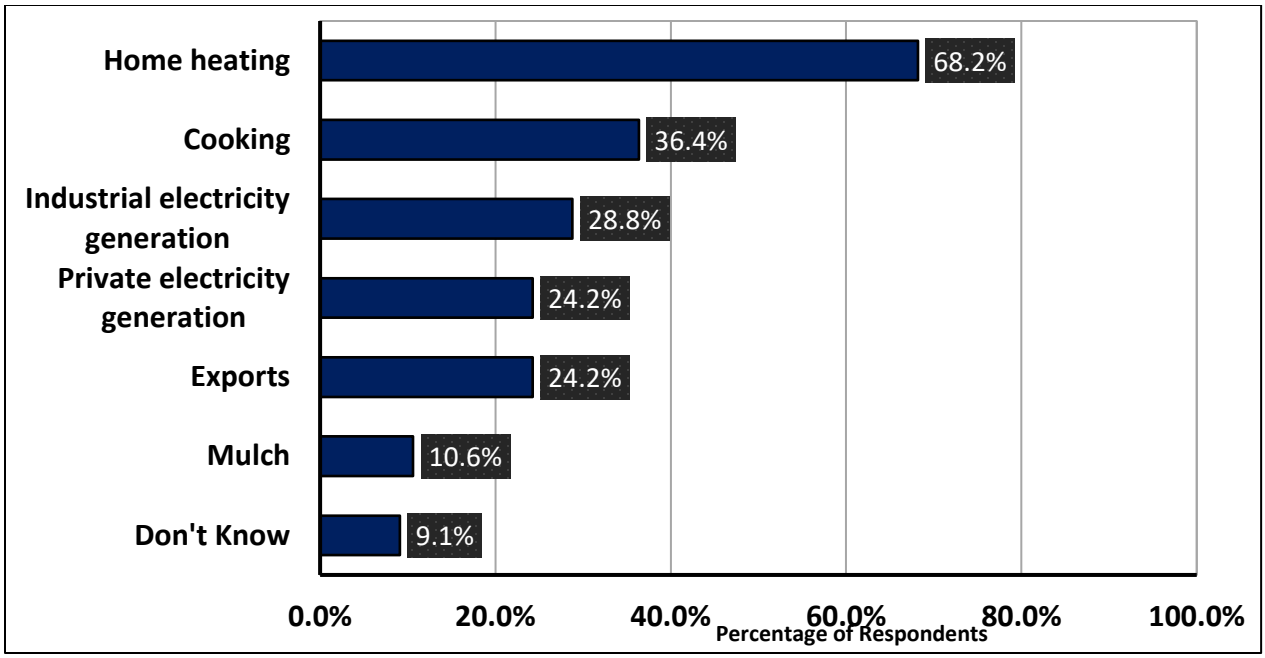

Figure B.10. What do you think wood pellets are used for? (n=66)(Multiple responses possible)

Table B.2. Please select your level of agreement with the following statements. (1=Strongly Disagree; 2= Somewhat Disagree; 3= Neutral; 4= Somewhat Agree; 5= Strongly Agree)

Item	n	Mean
When humans interfere with the environment it often produces disastrous consequences.	97	3.8
Humans are accelerating the rate of global warming.	98	3.5
If things continue on their present course, we will soon experience a major climate change catastrophe.	98	3.3
Climate change caused by humans has been greatly exaggerated.	96	2.9
Climate change is a naturally occurring phenomena, not caused by humans.	98	2.7
Humans will eventually learn enough about global warming to be able to control it.	98	2.7
Humans have the right to modify the environment to suit their needs.	97	2.6
Humans were meant to rule over the rest of nature.	98	2.4
The balance of nature is strong enough to cope with the impacts of industrialization.	96	2.2
Human economic needs are more important than protecting the environment.	97	2.0

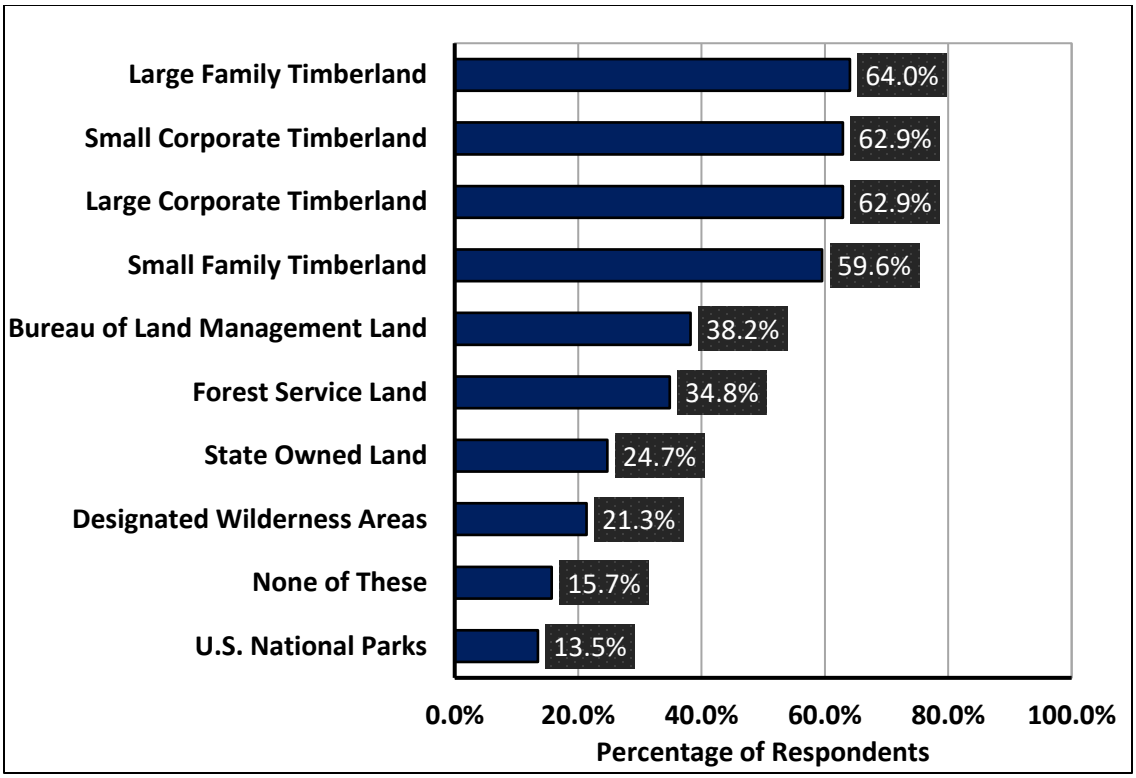

Figure B.11. Which types of ownership do you believe forests in the US should be harvested from for commercial products? (n=89)(Multiple responses possible)

Table B.3. Please select your level of agreement with the following statements. (1=Strongly Disagree; 2= Somewhat Disagree; 3= Neutral; 4= Somewhat Agree; 5= Strongly Agree)

Item	n	Mean
I am generally concerned about the natural resources in my community such as forests, air, and water.	91	4.3
It is important to me that the companies in my community do not harm the environment.	93	4.3
I am willing to be inconvenienced in order to participate in recycling that is environmentally friendly in my community.	93	4.0
I/my family recycles materials such as glass, plastic, and paper.	93	3.9
My community has a recycling program in place for materials such as glass, plastic, and paper.	92	3.7

Table B.5. Please select your level of agreement with the following statements. (1=Strongly Disagree; 2= Somewhat Disagree; 3= Neutral; 4= Somewhat Agree; 5= Strongly Agree)

Item	n	Mean
A strong economy is important to my community.	89	4.5
Job creation is important to my community.	90	4.3
My community has a strong economy.	89	3.6
Industry should stand on its own without government support/intervention.	91	3.3
State government should provide financial support to develop/maintain businesses in my community.	90	3.2
Local government should provide financial support to develop/maintain businesses in my community.	91	3.2
The Federal Government should provide financial support to develop/maintain businesses in my community.	91	3.1

Table B.6. Generally, what is your level of agreement regarding the need for the following sources of energy to be a priority in the United States? (1=Strongly Disagree; 2= Somewhat Disagree; 3= Neutral; 4= Somewhat Agree; 5= Strongly Agree)

Item	n	Mean
Solar	84	4.3
Hydro	81	4.2
Wind	84	4.1
Geothermal	83	3.8
Natural Gas	84	3.7
Agricultural Biomass	83	3.6
Wood Biomass	83	3.5
Oil	84	3.2
Coal	83	2.7

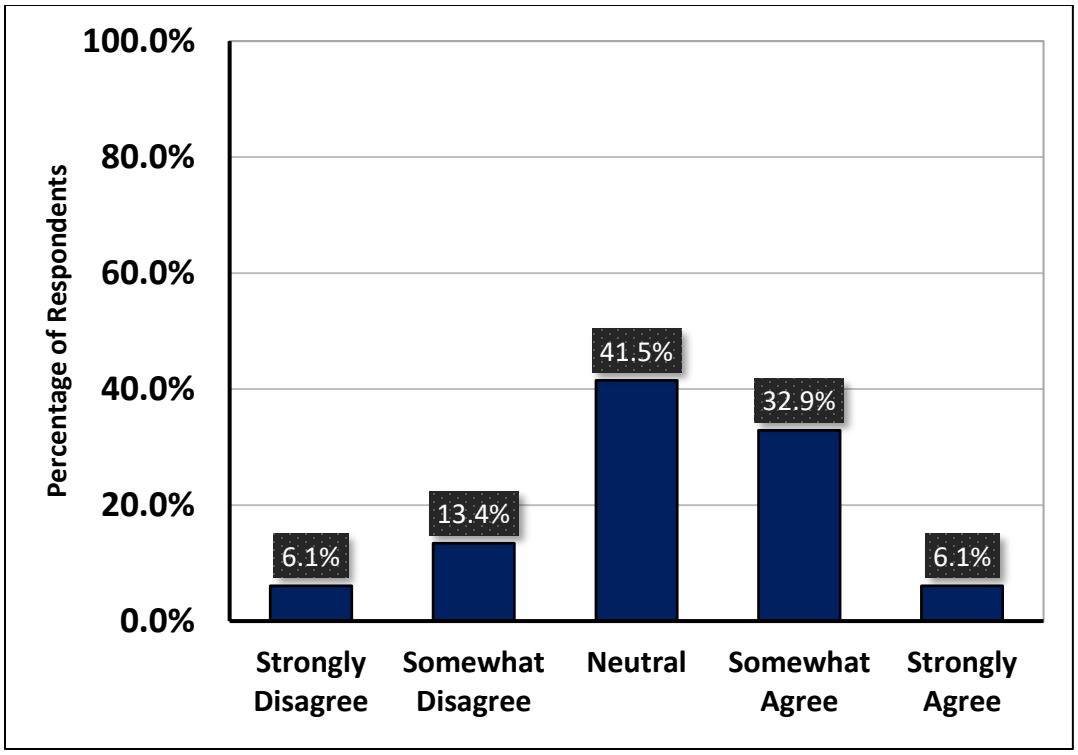

Figure B.12. In my opinion, wood pellets are a viable energy alternative to fossil fuels. (n=82)

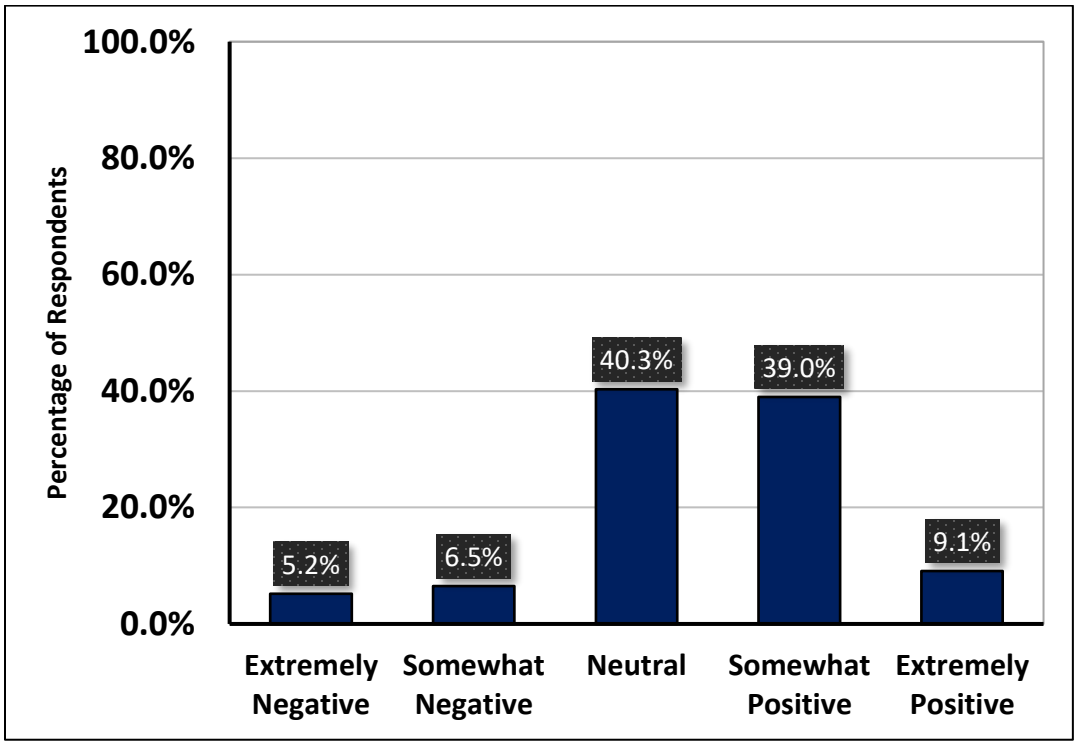

Figure B.13. In general, what is your overall opinion of using wood pellets for energy? (n=77)

Table B.7. Please indicate your level of agreement with the following statements regarding the wood pellet manufacturing industry. (1=Strongly Disagree; 2= Somewhat Disagree; 3= Neutral; 4= Somewhat Agree; 5= Strongly Agree)

Item	n	Mean
I think the wood pellet manufacturing industry utilizes appropriate forest management practices.	78	3.2
Wood pellets are an environmentally superior alternative method of energy generation relative to fossil fuels.	79	3.2
I trust the wood pellet manufacturing industry to act in the best interest of the environment.	78	3.2
Currently, the wood pellet manufacturing industry is effective in its efforts to help protect the environment.	78	3.2
Harvesting trees to manufacture wood pellets is not harmful to the environment.	79	3.0

Table B.8. Overall, I believe the wood pellet manufacturing industry's impacts on the following are: (1=Strongly Negative; 2= Somewhat Negative; 3= Neutral; 4= Somewhat Positive; 5= Strongly Positive)

Item	n	Mean
Sustainable Forests	73	3.0
Water Quality	73	3.0
Soil Quality	73	2.9
Forest-based Recreation	71	2.9
Wildlife Habitat	73	2.8
Air Quality	72	2.8

Table B.9. The wood pellet manufacturing industry: (1=Strongly Disagree; 2= Somewhat Disagree; 3= Neutral; 4= Somewhat Agree; 5= Strongly Agree)

Item	n	Mean
creates quality jobs.	67	3.4
contributes to community economic health.	68	3.2
is a good industry to work for.	68	3.2
is a superior industry for communities.	68	3.2
contributes to community activities and services.	68	3.0
is concerned about the needs of communities.	68	3.0

Table B.10. Please indicate your level of concern for the following issues associated with converting wood to pellets for energy production. (1=Not concerned at all; 2= Not very concerned; 3= Neutral; 4= Somewhat concerned; 5= Very concerned)

Item	n	Mean
Forest Degradation	63	3.8
Air Pollution	63	3.7
Damage to Forest Health	64	3.7
Road Quality/ Damage	63	3.6
Soil Degradation	63	3.6
Water Pollution	63	3.5
Safety Due to Increased Road Traffic	63	3.5
Wood Availability for Other Manufacturing Sectors	62	3.3
Noise Pollution from Log/ Chip Trucks	62	3.3
Noise Pollution from Pellet Manufacturers	63	3.2
Noise Pollution from Railways	63	3.0

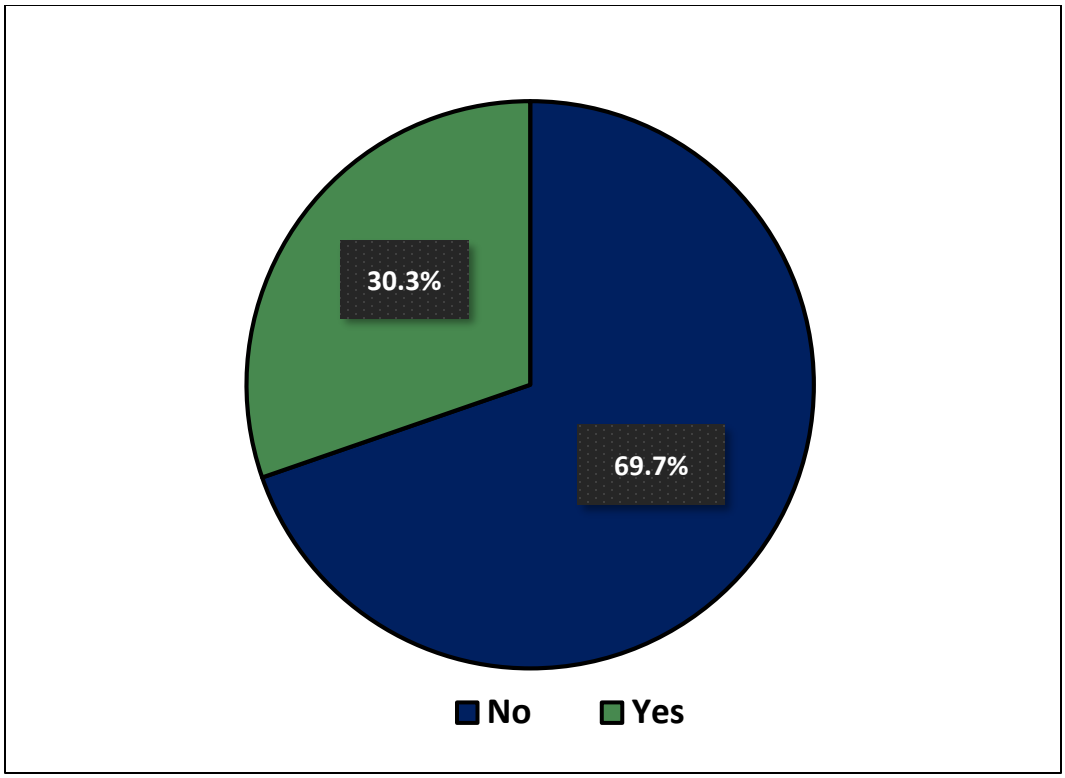

Figure B.14. Do you own forestland in the state that you live in? (n=66)

Table B.11. Approximately how many acres of forestland did you own in your state in 2018?

n	Minimum	Maximum	Mean	Std. Deviation
18	2.0	170.0	44.7	47.8

Table B.12. Please indicate the types of financial support local, state, and/ or federal governments should provide to the wood pellet manufacturing industry.

Item	Local	State	Federal	n
Property Tax Incentives	35.0%	37.5%	27.5%	40
Sales Tax Incentives	26.3%	60.5%	13.2%	38
Investment Tax Credits	17.1%	43.9%	39.0%	41
Job Creation Incentives	30.2%	46.5%	23.3%	43
Development Grants	14.3%	38.1%	47.6%	42

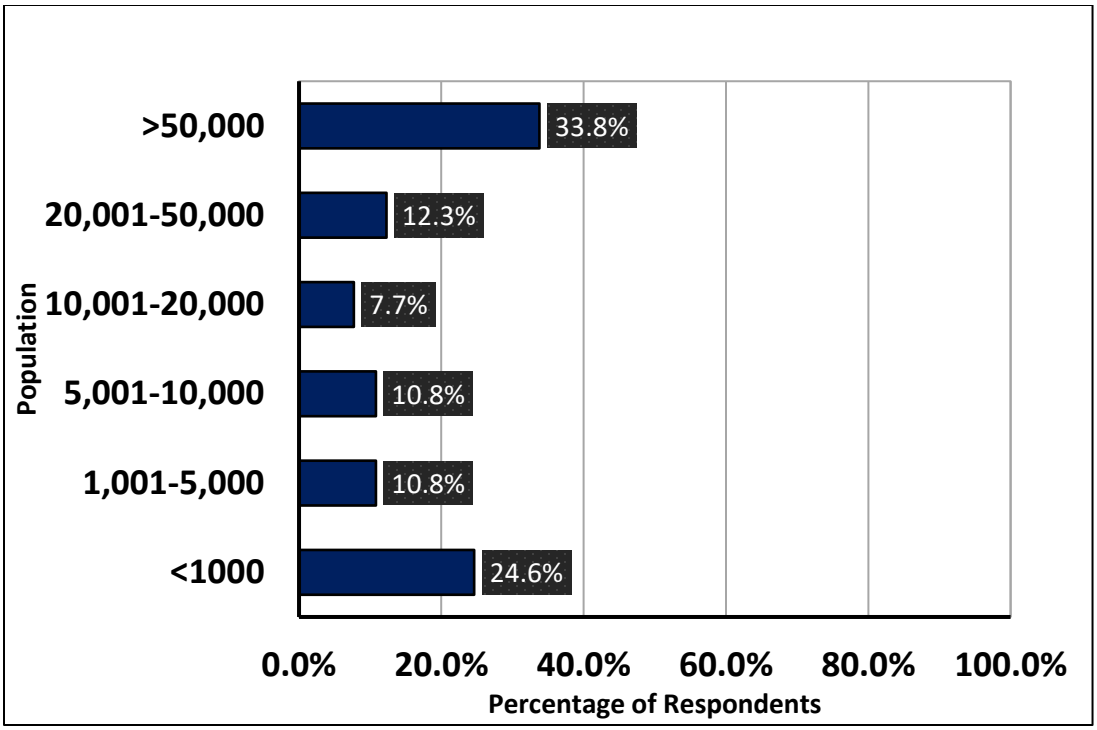

Figure B.15. Population of respondents' city/town (n=65)

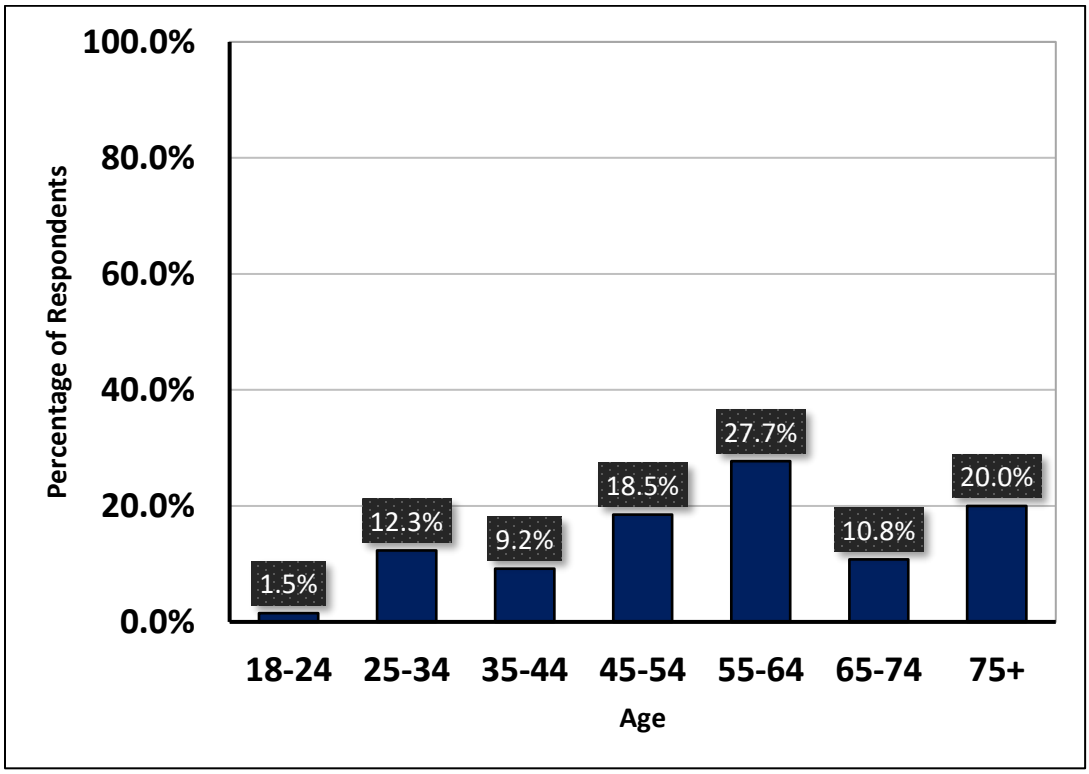

Figure B.16. Respondent age (n=65)

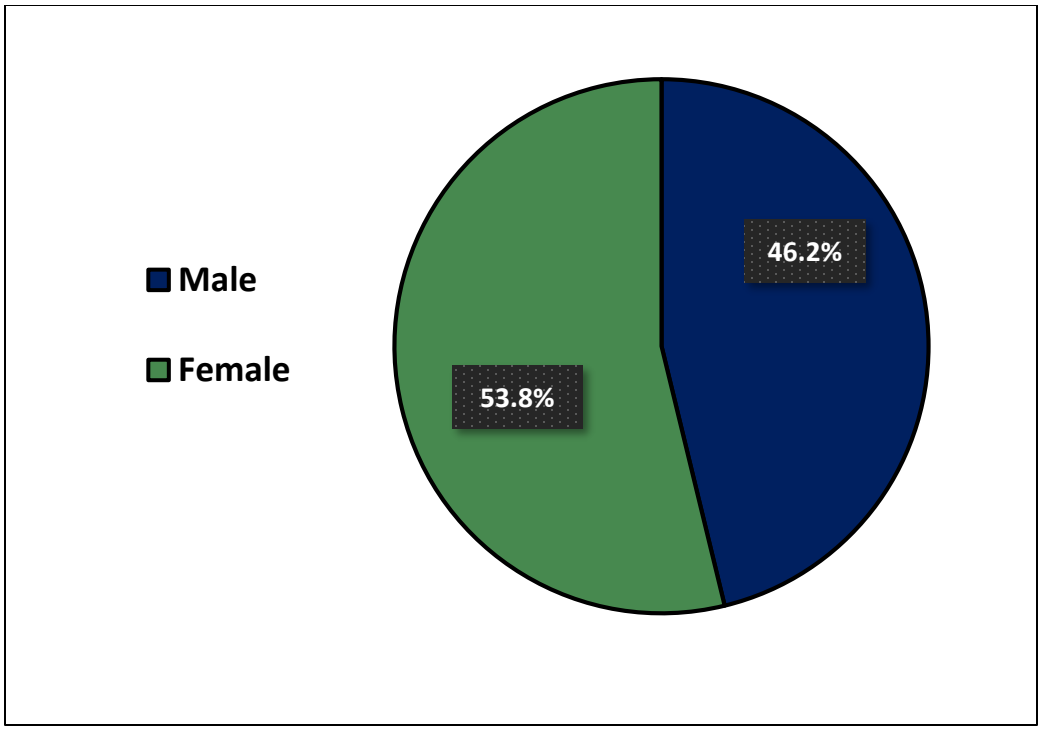

Figure B.17. Respondent gender (n=65)(Percentage of respondents)

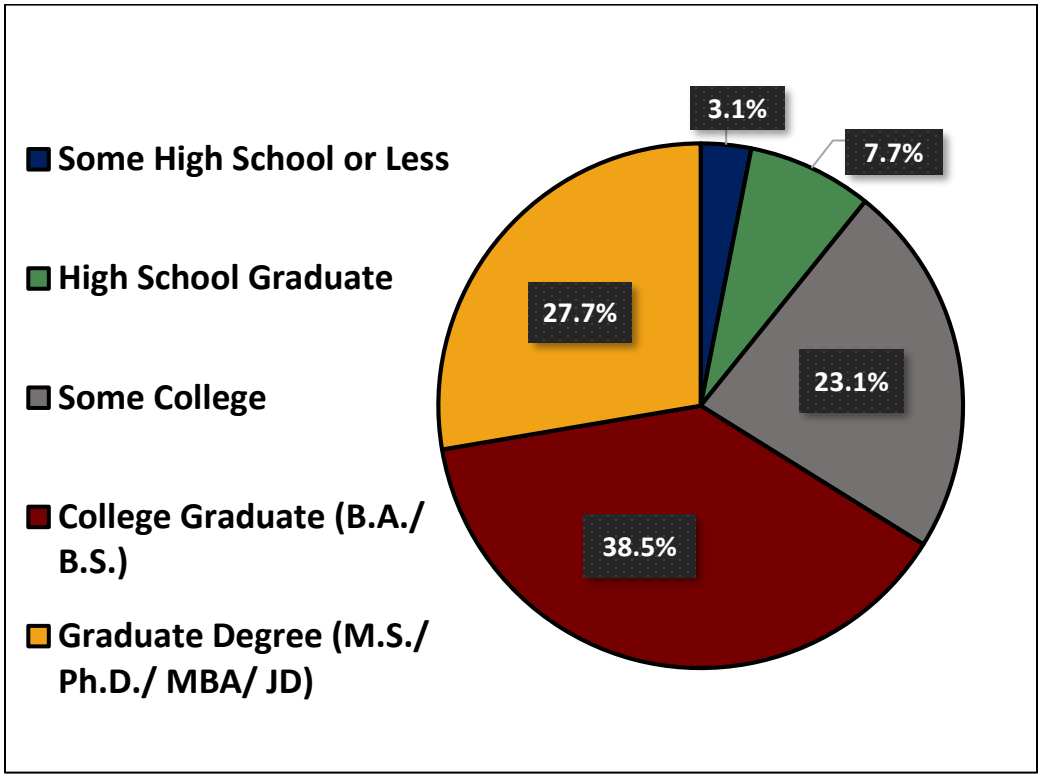

Figure B.18. Respondent level of education (n=65)(Percentage of respondents)

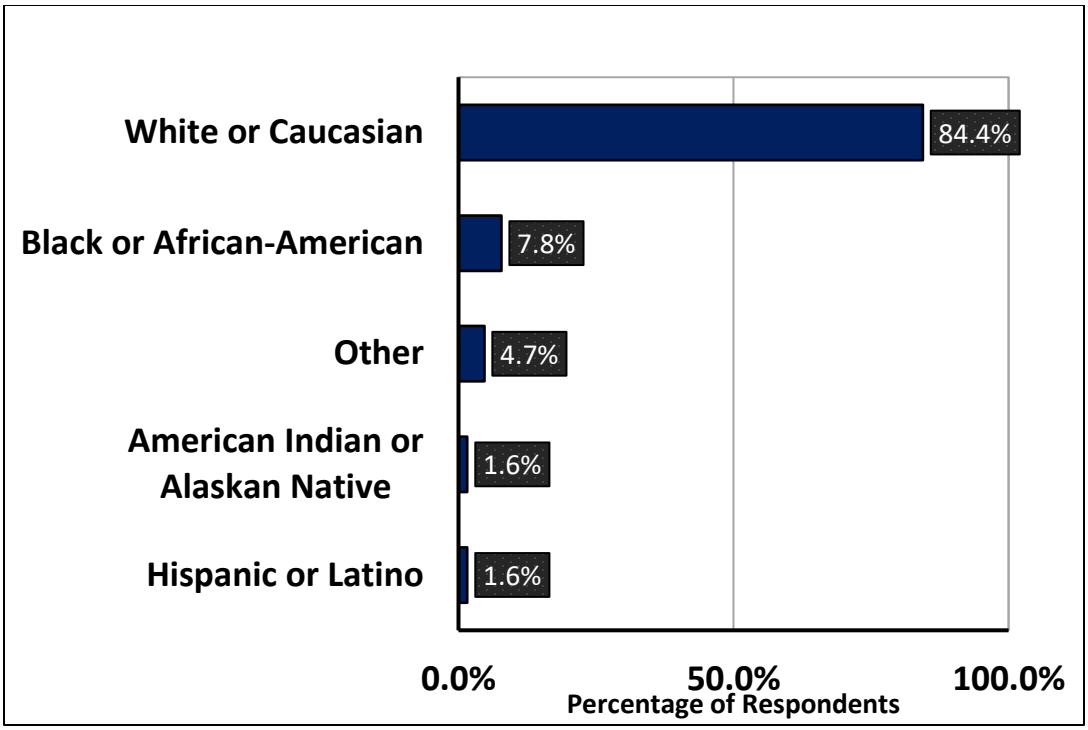

Figure B.19. Respondent ethnicity (n=64)

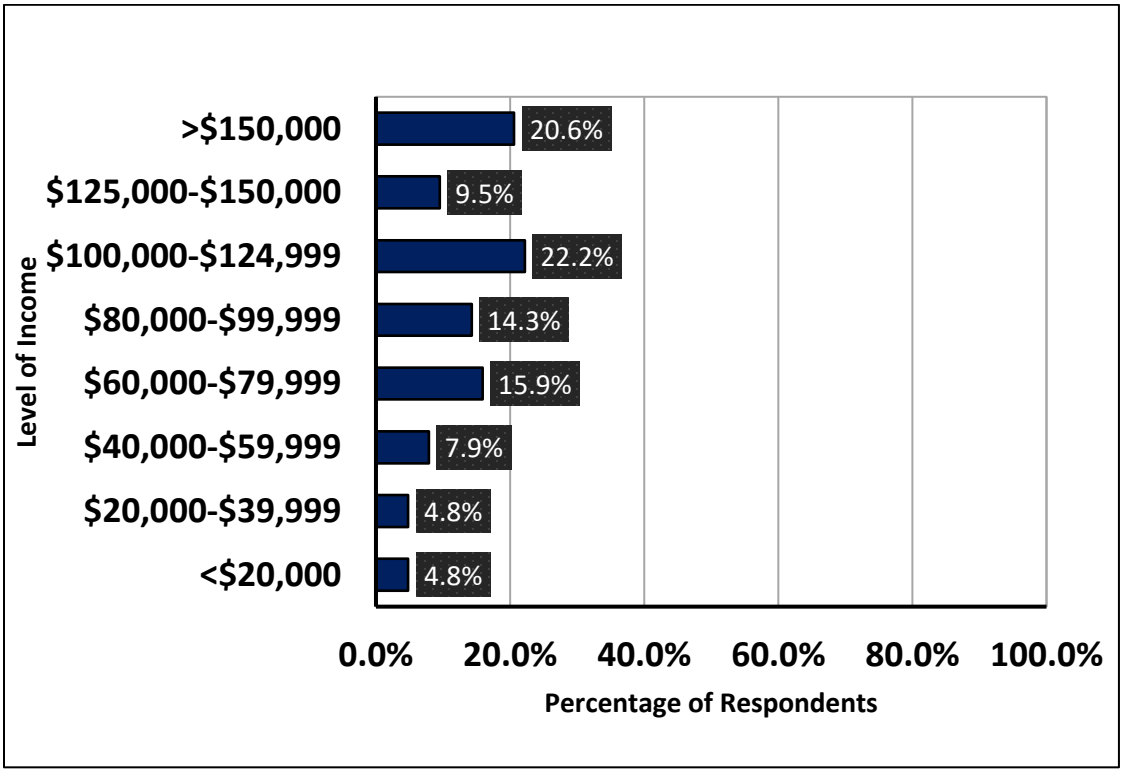

Figure B.20. Total combined income of all members of respondent household in 2018 (n=63)

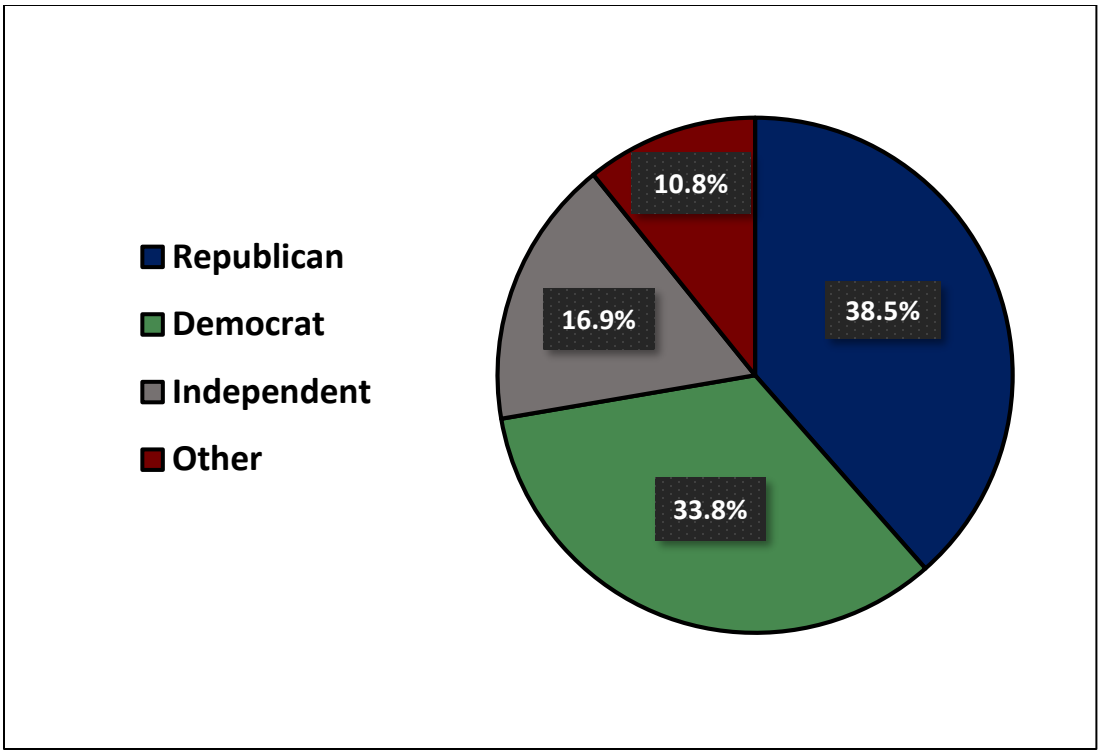

Figure B.21. Respondent political affiliation (n=65)(Percentages of respondents)

REFERENCES

Aguilar, F. X. & Cai, Z. (2010). Exploratory analysis of prospects for renewable energy private investment in the US *Energy Economics, 32*(6), 1245-1252.

Alberic, S., Boeve, S., Breevoort, P. V., Deng, Y., Forster, S., Gardiner, A., & Wouters, K. (2014). *Subsidies and costs of EU energy Final report* (Rep. No. DESNL14583). European Commission. Retrieved February 26, 2019, from https://ec.europa.eu/energy/sites/ener/files/documents/ECOFYS%202014%20Subsidies%20and%20costs%20of%20EU%20energy_11_Nov.pdf

Anderson, N. & Mitchell. D. (2016). Forest operations and woody biomass logistics to improve efficiency, value, and sustainability. *Bioenergy Research, 9*(2), 518-533.

Anderson, P., & Powell, K. (2018). Dirty Deception: How the Wood Biomass Industry Skirts *the Clean Air Act* (Report). Environmental Integrity Project.

Armstrong, J. S., & Overton, T. S. (1977). Estimating Nonresponse Bias in Mail Surveys. *Journal of Marketing Research, 14*(3), 396–402.

Arrhenius, S. (1896). On the Influence of Carbonic Acid in the Air upon the Temperature of the Earth. *Philosophical Magazine and Journal of Science, 41*, 5th ser., 237-276.

BBI International. (2018, April). 2018 US & Canada Pellet Mill Map. In *BBI International*.

BBI International. (2019, April). 2019 US & Canada Pellet Mill Map. In *BBI International*. Retrieved April 1 2018, from http://store.bbiinternational.com/2018-US-Canada-Pellet-Mill-Map-P18.aspx

Beagle, E. & Belmont, E. (2019). Comparative life cycle assessment of biomass utilization for electricity generation in the European Union and the United States. *Energy Policy, 128*, 267-275.

Bearden, W. O., Netemeyer, R. G., & Haws, K. L. (2011). Customer-Based Reputation of a Service Firm: CBR Scale. In *Handbook of Marketing Scales* (3rd ed., pp. 394-396). Thousand Oaks, CA: SAGE Publications.

Bearden, W. O., Netemeyer, R. G., & Haws, K. L. (2011). GREEN Consumer Values. In *Handbook of Marketing Scales* (3rd ed., pp. 172-173). Thousand Oaks, CA: SAGE Publications.

Biomass Crop Assistance Program (BCAP). (2019). Retrieved April 3, 2019, from https://www.fsa.usda.gov/programs-and-services/energy-programs/BCAP/index

Boby, L., Hitchner, S., Hubbard, W., Dasmohaparta, S., Radics, R., & Shelhas, J. (2016). *Public Perceptions of Bioenergy* (Publication No. SREF-BE-003). Athens, GA: Southern Regional Extension Forestry. Retrieved April 29, 2019, from https://sref.info/resources/publications/public-perceptions-of-bioenergy/?searchterm=Public%20Perceptions%20of%20Bioenergy

Bock, B. B. (2016). Rural Marginalisation and the Role of Social Innovation; A Turn Towards Nexogenous Development and Rural Reconnection. *Sociologia Ruralis, 56*(4), 552-573.

Bodansky, D. (2001). The History of the Global Climate Change Regime. In U. Luterbacher & D. F. Sprinz (Authors), *International relations and global climate change* (pp. 23-40). Cambridge, MA: MIT Press.

Bolin, B. R. (2008). A history of the science and politics of climate change: The role of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Brandeis, C., & Guo, Z. (2016). Decline in the Pulp and Paper Industry: Effects on Backward-Linked Forest Industries and Local Economies. *Forest Products Journal, 66*(3/4), 113.

Brook, R. D., Rajagopalan, S., Pope, C. A., Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., Kaufman, J. D. (2010). Particulate Matter Air Pollution and Cardiovascular Disease. *Circulation, 121*(21), 2331-2378.

Brown, D. L., & Shucksmith, M. (2017). Reconsidering Territorial Governance to Account for Enhanced Rural-Urban Interdependence in America. *The ANNALS of the American Academy of Political and Social Science, 672*(1), 282–301.

Bruner, G. C., Jr. & Hensel, P. J. (1994). #48Community Mindedness. In *Marketing Scales Handbook* (pp. 125-127). Chicago, IL: American Marketing Association.

Bruner, G. C., Jr., James, K. E., & Hensel, P. J. (2001). #225 Knowledge (Product Class). In *Marketing Scales Handbook* (Vol. 3, pp. 364-365). Chicago, IL: American Marketing Association.

Bruner, G. C., Jr., James, K. E., & Hensel, P. J. (2001). #388 Trust in Source's Position Toward the Environment. In *Marketing Scales Handbook* (Vol. 3, pp. 636-637). Chicago, IL: American Marketing Association.

Bruner, G. C., Jr., James, K. E., & Hensel, P. J. (2001). #147 Environmental Paradigm. In *Marketing Scales Handbook* (Vol. 3, pp. 229-230). Chicago, IL: American Marketing Association.

Bruner, G. C., Jr., James, K. E., & Hensel, P. J. (2001). #47 Attitude Toward the Business (Overall). In *Marketing Scales Handbook* (Vol. 3, p. 75). Chicago, IL: American Marketing Association.

Bureau of Economic Analysis. (2018). South vs. United States | Total Industry Earnings Trends over 1958-2017. Retrieved December 6, 2018, from https://united-states.reaproject.org/analysis/comparative-trends-analysis/total_industry_earnings/tools/10050000/0/

Callendar, G. S. (1938). The artificial production of carbon dioxide and its influence on temperature. *Quarterly Journal of the Royal Meteorological Society, 64*(275), 223-240.

Campbell, R, Campbell, M, & Hughes, C. (2004). *A Revolution in the Heartland: Changes in* Rural Culture, Family and Communities 1900-2000. Missouri: University of Missouri Extension.

Carpenter, K. E., Abrar, M., Aeby, G., Aronson, R. B., Banks, S., Bruckner, A., Wood, E. (2008). One-third of reef-building corals face elevated extinction risk from climate change and local impacts. *Science, 321*(5888), 560-563.

Castro, A. (2012). Rural families and their transformation processes: Case studies in a scenario of stressful rurality. *Psychoperspective, 11*(1), 180-203.

Committee on Climate Change (CCC). (2018). *Reducing UK emissions 2018: Progress Report to Parliament* (Rep. No. 10). London: CCC.

Committee on Climate Change (CCC). (2019). Legal duties on climate change. Retrieved February 13, 2019, from https://www.theccc.org.uk/tackling-climate-change/the-legal-landscape/

Copley, A. (2018, January 08). Consolidation of Wood Pellet Producers Continues. Retrieved October 23, 2018, from http://forisk.com/blog/2018/01/05/consolidation-wood-pellet-producers-continues/

Council for Community and Economic Research (CCER). (2019). State Business Incentives Database. Retrieved April 8, 2019, from http://www.stateincentives.org/

Dale, V. H., Parish, E., Kline, K. L., & Tobin, E. (2017). How is wood-based pellet production affecting forest conditions in the southeastern United States? *Forest Ecology and Management, 396*, 143-149.

Davies, A. R. (1999). Where do we go from here? Environmental focus groups and planning policy formation. *Local Environment, 4*(3), 295.

Deffenbaugh, N. S., Singh, D., Mankin, J. S., Horton, D. E., Swain, D. L., Touma, D., Rajaratnam, B. (2017). Quantifying the influence of global warming on unprecedented extreme climate events. *Proceedings of the National Academy of Sciences of the United States of America*, *114*(19), 4881-4886.

Dewhurst, J.F. (1955). *America's Needs and Resources: A New Survey*. New York, NY: The Twentieth Century Fund.

Diaz-Chavez, R., Walter, A., and Gerber, P. (2019). *Socio-economic assessment of the pellets supply chain in the USA*. IEA Bioenergy Task 40.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, Phone, Mail, and Mixed-Mode* Surveys: The Tailored Design Method, 4th Edition. New York, NY: John Wiley& Sons.

Dogwood Alliance. (2016). Vanishing Treasures: Threatened Wetland Forest In The Southern US Need To Be A National Conservation Priority (Rep.). Asheville, NC: Dogwood Alliance.

Drax. (2019). Our history. Retrieved March 18, 2019, from https://www.drax.com/about-us/our-history/

Dunlap, R. E., Liere, K. D. V., Mertig, A. G., & Jones, R. E. (2000). New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. *Journal of Social Issues*, *56*(3), 425–442.

Durkheim, E. (1893). Émile Durkheim on The division of labor in society. Paris, France: University Press of France.

Dwivedi, P., Khanna, M., Bailis, R., & Ghilardi, A. (2014). Potential greenhouse gas benefits of transatlantic wood pellet trade. *Environmental Research Letters, 9*(2).

Dwivedi, P., Johnson, E., Greene, D., & Baker, S. (2016). Tracking Economic and Environmental Indicators of Exported Wood Pellets to the United Kingdom from the Southern United States: Lessons for Policy? *BioEnergy Research, 9*(3), 907-916.

Easterling, D. R., Meehl, G. A., Parmesan, C., Changnon, S. A., Karl, T. R., & Mearns, L. O. (2000). Climate Extremes: Observations, Modeling, and Impacts. *Science*, *289*(5487), 2068–2074.

Environmental Protection Agency (EPA). (2019). The Kyoto Protocol. Retrieved February 8, 2019, from http://www.epa.ie/climate/thekyotoprotocol/

European Commission. (1997). Energy for the Future: Renewable Sources of Energy [White Paper]. Retrieved February 14, 2019, from http://europa.eu/documents/comm/white_papers/pdf/com97_599_en.pdf

European Commission. (2001). Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market. *Official Journal of the European Union*, L283, 33-40. Retrieved February 18, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32001L0077

European Commission. (2005). *Communication from the Commission: Biomass action plan*. Retrieved February 18, 2019, from https://publications.europa.eu/en/publication-detail/-/publication/e414963a-9a01-4fcf-ab43-c8586c4d795b/language-en.

European Commission. (2009a). Directive 2009/28/EC of the European Parliament and the Council of 23 April 2009 on the Promotion of the use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC. *Official Journal of the European Union*, L140/16, 39-85. Retrieved February 18, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32009L0028.

European Commission. (2009b). The Renewable Energy Progress Report: Commission Report in accordance with Article 3 of Directive 2001/77/EC, Article 4(2) of Directive 2003/30/EC and on the implementation of the EU Biomass Action Plan, COM(2005)628(Report No. 192). Brussels: European Commission. Retrieved February 18, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52009DC0192

European Commission. (2015). Directive 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality control of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the Use of energy from renewable resources. *Official Journal of the European Union*, L239, 1-29. Retrieved February 18, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32015L1513.

European Commission. (2017, February 16). Kyoto 1st commitment period (2008–12). Retrieved February 14, 2019, from https://ec.europa.eu/clima/policies/strategies/progress/kyoto_1_en

European Commission. (2018a, June 20). Renewable energy. Retrieved February 18, 2019, from https://ec.europa.eu/energy/en/topics/renewable-energy

European Commission. (2018b). Directive 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). *Official Journal of the European Union*, L328, 82-209. Retrieved February 18, 2019, from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

European Commission. (2019a, February 14). Clean energy for all Europeans. Retrieved February 18, 2019, from https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans

European Commission. (2019b, February 16). Land use and forestry regulation for 2021-2030. Retrieved February 19, 2019, from https://ec.europa.eu/clima/lulucf_en#tab-0-0

European Parliament, News Press. (2018, November 13). *Energy: New ambitious targets on renewables and energy efficiency* [Press release]. Retrieved November 15, 2018, from http://www.europarl.europa.eu/news/en/press-room/20181106IPR18315/energy-new-ambitious-targets-on-renewables-and-energy-efficiency

Export.gov. (2018, September 6). Korea - Energy New and Renewable Korea - Energy New and Renewable. Retrieved February 26, 2019, from https://www.export.gov/article?id=Korea-Energy-New-and-Renewable

Farm Service Agency (FSA). (2010, October). *Biomass Crop Assistance Program (BCAP)* (US, US Department of Agriculture, Farm Service Agency). Retrieved April 3, 2019, from https://www.fsa.usda.gov/Internet/FSA_File/bcapoctrules.pdf

Farm Service Agency (FSA). (2016). Biomass Crop Assistance Program (BCAP) Qualified Biomass Conversion Facilities (BCF's) FY 2016. Retrieved April 3, 2019, from https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Energy/bcap_facility_listing_FY2016.pdf

Flach, B., Lieberz, S., Lappin, J., & Bolla, S. (2018). *EU Biofuels Annual 2018*(United States, USDA, Foreign Agricultural Service). Washington D.C.: USDA.

Flach, B., Lieberz, S., & Bolla, S. (2019). *EU Biofuels Annual 2019*(United States, USDA, Foreign Agricultural Service). Washington D.C.: USDA.

Flach, B. (2019). *The Dutch Industrial Market for Biomass* (United States, USDA, Foreign Agriculture Service). Washington D.C.: USDA. Retrieved March 16, 2019, from https://gain.fas.usda.gov/Recent%20GAIN%20Publications/The%20Dutch%20Industrial%20Market%20for%20Biomass_The%20Hague_Netherlands_2-5-2019.pdf

Food and Agriculture Organization of the United Nations (UN-FAO). (2018). *Forest Products Annual Market Review 2017-2018*(Publication). Geneva: United Nations.

Forest2Market. (2017, July 27). Forest2Market Report Shows Increased Demand for Wood Fiber Leads to Forest Growth. Retrieved April 2, 2019, from https://blog.forest2market.com/forest2market-report-shows-increased-demand-for-wood-fiber-leads-to-forest-growth

Forest2Market. (2018). Demand for Biomass pellets and Chips: Japan and South Korea. Charlotte, NC: Forest2Market. Retrieved March 19, 2019, from https://cdn2.hubspot.net/hubfs/299583/2016_Website/Documents/Asian%20Campaign/Demand%20for%20Biomass%20Pellets%20Chips%20from%20Biopower%20Producers%20in%20Japan%20South%20Korea.pdf?t=1519223939422

Franks, D. M., Davis, R., Bebbington, A. J., Ali, S. H., Kemp, D., & Scurrah, M. (2014). Conflict translates environmental and social risk into business costs. *Proceedings of the National Academy of Sciences, 111*(21), 7576-7581.

Giving Back. (2019). Retrieved June 5, 2019, from http://www.envivabiomass.com/sustainability/strong-communities/giving-back/

Goetzl, A. (2015, January). Developments in the Global Trade of Wood Pellets (Working paper No. ID-039). Retrieved March 20, 2019, from United States International Trade Commission website: https://www.usitc.gov/publications/332/wood_pellets_id-039_final.pdf

Greene, J. (2019, March 4). US Wood Pellet Exports Increased 17% in 2018. Retrieved March 20, 2019, from https://blog.forest2market.com/us-wood-pellet-exports-increased-17-percent-in-2018

Gunnerman, R. (1977). *United States Patent No. 4,015,951*. Retrieved March 7, 2019, from https://patentimages.storage.googleapis.com/a6/cb/58/c5d1f8a6b193b5/US4015951.pdf

Gunningham, N., Kagan, R. A., & Thornton, D. (2003). *Shades of green: business,* regulation, and environment. Stanford University Press.

Gunningham, N., Kagan, R. A., & Thornton, D. (2004). Social License and Environmental Protection: Why Businesses Go Beyond Compliance. *Law and Social Inquiry, 29*(2), 307-342.

Gupta, J. (2010). A history of international climate change policy. *Wiley Interdisciplinary Reviews: Climate Change, 1*(5), 636-653.

Henderson, J. E., Joshi, O., Parajuli, R., & Hubbard, W. G. (2017). Research paper: A regional assessment of wood resource sustainability and potential economic impact of the wood pellet market in the US South. *Biomass and Bioenergy, 105*, 421-427.

Hitchner, S., Schelhas, J., Hujala, T., & Brosius, J. P. (2014b). Chapter 2: Public opinion and wood energy. In *Wood Energy in Developed Economies* (pp. 32-74). New York, NY: Routledge.

Hulme, M. (1998). Global warming. *Progress in Physical Geography, 22*(3), 398-406.

Intergovernmental Panel on Climate Change, Houghton, J. T., & World Meteorological Organization (IPCC). (1990). IPCC first assessment report. Geneva: WMO.

Intergovernmental Panel on Climate Change (IPCC). (2007). Summary for Policymakers. *Climate Change 2007: The Physical Science Basis*.

International Energy Agency (IEA). (2019a). IEA World Energy Balances. Retrieved June 6, 2019, from https://www.iea.org/statistics/balances/

International Energy Agency (IEA). (2019b). Feed-in Tariff for renewable electricity and solar PV auction. Retrieved February 26, 2019, from https://www.iea.org/policiesandmeasures/pams/japan/name-30660-en.php

Jefferies, H. (2016, June 3). NAFO Report Highlights Part 2: Economic Impact of Forest Products Industry. Retrieved December 6, 2018, from https://blog.forest2market.com/nafo-report-highlights-part-2-economic-impact-of-forest-products-industry

Johnson, R., & Scicchitano, J. (2012). Don't Call Me NIMBY: Public Attitudes Toward Solid Waste Facilities. *Environment and Behavior, 44*(3), 410–426.

Kahan, P. R. (1996). State Economic Development Incentives. *Tax Executive,* (Issue 6), 445. Retrieved April 11, 2019, from http://web.a.ebscohost.com/ehost/detail/detail?vid=1&sid=f0a906a2-86c9-4308-865e-76440540ebcc%40sdc-v-sessmgr03&bdata=JnNpdGU9ZWhvc3QtbGl2ZSZzY29wZT1zaXRl#AN=9707102972&db=bth

Karmen, B. (2014). Biomass Crop Assistance Program 1-BCAP Amendment 4(United States, USDA). Washington D.C. Retrieved April 3, 2019, from https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Energy/1bcap-a4.pdf

Kim, P. (2018, July 11). Global Climate Change: Scientific Consensus, Political Challenge. Retrieved May 28, 2019, from https://www.fpi.sais-jhu.edu/single-post/2016/07/20/Global-Climate-Change-Scientific-Consensus-Political-Challenge

Koester, S., & Davis, S. (2018). Siting of Wood Pellet Production Facilities in Environmental Justice Communities in the Southeastern United States. *Environmental Justice, 11*(2), 64-70.

Korea Energy Agency (KEA). (2019). Renewables. Retrieved February 26, 2019, from http://www.energy.or.kr/renew_eng/new/standards.aspx

Kreutzweiser, D. P., Hazlett, P. W., & Gunn, J. M. (2008). Logging impacts on the biogeochemistry of boreal forest soils and nutrient export to aquatic systems: A review. *Environmental Reviews, 16*(NA), 157-179.

Kutney, G. (2016, May 30). A Short History of Biofuels. Retrieved February 12, 2019, from https://lee-enterprises.com/a-short-history-of-biofuels/

Lesk, C., Rowhani, P., & Ramankutty, N. (2016). Influence of extreme weather disasters on global crop production. *Nature*, *529*(7584), 84–87.

Levitt, T. (2016). Partners for good: business, government and the third sector. S.I.: Routledge.

Lindroos A., Tamminen, P., Heikkinen, J., & Ilvesniemi, H. 2016: Effect of clear-cutting and the amount of logging residue on chemical composition of percolation water in spruce stands on glaciofluvial sandy soils in southern Finland. *Boreal Env. Res. 21*, 134–148.

Lisle, B. (2013). The History of the Wood Pellet Industry on the East Coast. In *Wood-Based Energy in the Northern Forests* (pp. 153-160). New York, NY: Springer.

Lloyd, D., Luke, H., & Boyd, B. (2013). Community perspectives of natural resource extraction: coal-seam gas mining and social identity in Eastern Australia. *Coolabah,* (10), 144-164.

Loe, J. S., & Kelman, I. (2016). Arctic petroleum's community impacts: Local perceptions from Hammerfest, Norway. *Energy Research & Social Science, 16*, 25-34.

Louisiana Economic Development Board of Commerce & Industry (LCBI). (2013). Louisiana Commerce and Industry Board Approvals 2014. Retrieved August 8, 2019, from https://www.opportunitylouisiana.com/docs/default-source/Performance-Reporting/c-i-board-approvals/2013_ci_board_approvals.pdf?sfvrsn=95b2d405_4

Louisiana Economic Development Board of Commerce & Industry (LCBI). (2014). Louisiana Commerce and Industry Board Approvals 2014. Retrieved August 8, 2019, from https://www.opportunitylouisiana.com/docs/default-source/Performance-Reporting/c-i-board-approvals/2014_ci_board_incentive_approvals.pdf?sfvrsn=87b2d405_2

Louisiana Economic Development (LED). (2019a). Louisiana Economic Development. Retrieved April 10, 2019, from https://www.opportunitylouisiana.com/business-incentives

Louisiana Economic Development (LED). (2019b). Agribusiness: Competitive Cost. Retrieved April 10, 2019, from https://www.opportunitylouisiana.com/key-industries/agribusiness/competitive-costs

Lüthi, D., M. Le Floch, B. Bereiter, T. Blunier, J.-M. Barnola, U. Siegenthaler, … T.F. Stocker. (2008). High-resolution carbon dioxide concentration record 650,000-800,000 years before present. *Nature*, 453, 379-382.

Magelli, F., Boucher, K., Bi, H. T., Melin, S., & Bonoli, A. (2009). An environmental impact assessment of exported wood pellets from Canada to Europe. *Biomass and Bioenergy*, *33*(3), 434-441.

Meador, J. E. (2019). Reaching rural: Identifying implicit social networks in community development programmes. *Journal of Rural Studies*, *68*, 285-295.

Meehl, G. A., & Tebaldi, C. (2004). More Intense, More Frequent, and Longer Lasting Heat Waves in the 21st Century. *Science*, *305*(5686), 994–997.

Meyskens, M., Carsrud, A. L., & Cardozo, R. N. (2010). The symbiosis of entities in the social engagement network: The role of social ventures. *Entrepreneurship & Regional Development*, *22*(5), 425–455.

Ministry announces 8th Basic Plan for Electricity Supply and Demand. (2017, December 15). Retrieved October 23, 2018, from http://english.motie.go.kr/en/tp/energy/bbs/bbsView.do?bbs_seq_n=605&bbs_cd_n=2&view_type_v=TOPIC&¤tPage=1&search_key_n=&search_val_v=&cate_n=3

Ministry of Economy, Trade, and Industry (METI). (2002). *Basic Act on Energy Policy*. Retrieved February 25, 2019, from http://www.japaneselawtranslation.go.jp/law/detail/?vm=04&re=02&id=123&lvm=01

Ministry of Economy, Trade, and Industry (METI). (2012). Feed in tariff scheme in Japan. Retrieved February 26, 2019, from http://www.enecho.meti.go.jp/category/saving_and_new/saiene/kaitori/surcharge.html

Ministry of Economy, Trade, and Industry (METI). (2014). Strategic Energy Plan. Retrieved February 25, 2019, from http://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/4th_strategic_energy_plan.pdf

Ministry of Economy, Trade, and Industry (METI). (2018). Strategic Energy Plan. Retrieved February 25, 2019, from http://www.enecho.meti.go.jp/en/category/others/basic_plan/5th/pdf/strategic_energy_plan.pdf

Ministry of Trade, Industry and Energy (MoTIE). (2014, December 30). Promotion of new and renewable energy. Retrieved February 26, 2019, from http://english.motie.go.kr/en/tp/alltopics/bbs/bbsView.do?bbs_cd_n=3&bbs_seq_n=19#page2

Ministry of Trade, Energy, and Industry (MoTIE). (2015). *Act on the Promotion of the Development, Use and Diffusion of New and Renewable Energy*. Retrieved February 26, 2019, from http://extwprlegs1.fao.org/docs/pdf/kor70352.pdf

Ministry of Trade, Energy, and Industry (MoTIE). (2017, December 15). Ministry announces 8th Basic Plan for Electricity Supply and Demand. Retrieved February 26, 2019, from http://english.motie.go.kr/en/tp/energy/bbs/bbsView.do?bbs_seq_n=605&bbs_cd_n=2&view_type_v=TOPIC&&currentPage=1&search_key_n=&search_val_v=&cate_n=3

Mississippi Development Authority (MDA). (2018). *FY2017 Mississippi incentives Report* (Rep.). Jackson, MS. Retrieved April 10, 2019, from https://d71ad12c3ec51c77ff3d-a5f8631cb8ff4476a529cdcf2eaaa70e.ssl.cf5.rackcdn.com/2018/02/FY2017-Incentives-Report-Final.pdf

Moffat, K., Lacey, J., Zhang, A., & Leipold, S. (2015). The social licence to operate: A critical review. *Forestry*, *89*(5), 477-488.

Morrison, B., & Golden, J. S. (2016). Southeastern United States wood pellets as a global energy resource: A cradle-to-gate life cycle assessment derived from empirical data. *International Journal of Sustainable Energy*, *37*(2), 134-146.

Morrison, B., Daystar, J., & Golden, J. S. (2018). Substituting wood pellets for coal in large-scale power stations: A dynamic life cycle assessment examination. *International Journal of Global Energy Issues, 41*(5/6), 272-288.

Nagelkerken, I., & Munday, P. L. (2015). Animal behaviour shapes the ecological effects of ocean acidification and warming: moving from individual to community-level responses. *Global Change Biology*, *22*(3), 974–989.

National Aeronautics and Space Administration (NASA). (2019, May 15). Carbon Dioxide Concentration. Retrieved May 29, 2019, from https://climate.nasa.gov/vital-signs/carbon-dioxide/

National Institute of Food and Agriculture (NIFA). (2019). Bioeconomy, Bioenergy, & Bioproducts (B3) Programs. Retrieved May 8, 2019, from https://nifa.usda.gov/program/bioeconomy-bioenergy-bioproducts-b3-programs

National Oceanic and Atmospheric Administration (NOAA). (2019, August 7). Assessing the U.S. Climate in July 2019. Retrieved August 30, 2019, from https://www.ncei.noaa.gov/news/national-climate-201907

North Carolina Department of Commerce. (2019). Grants and Incentives. Retrieved June 6, 2019, from https://www.nccommerce.com/grants-incentives

Nykvist, N., & Rosén, K. (1985). Effect of clear-felling and slash removal on the acidity of Northern coniferous soils. *Forest Ecology and Management, 11*(3), 157-169.

Ofgem. (2017, August 23). About the RO. Retrieved February 27, 2019, from https://www.ofgem.gov.uk/environmental-programmes/ro/about-ro

Ørsted. (2019). *Avedøre Power Station* [Brochure]. Author. Retrieved March 14, 2019, from https://orsted.com/-/media/WWW/Docs/Corp/COM/Our-business/Bioenergy-and-Thermal-Power/Plants-brochures/Avedrevrket_Brochure_ENG_WEB.ashx?la=en&hash=7667D72F80910B41B94562CA08BA9EF7A202ADEC&hash=7667D72F80910B41B94562CA08BA9EF7A202ADEC

Oswalt, S. N., Smith, W. B., Darr, D., Langner, L., Miles, P., Nelson, M., Paschke, J. (2014). *US Forest Resource Facts and Historical Trends* (Rep. No. FS-1035). Washington D.C.: USDA. Retrieved April 2, 2019, from https://www.fia.fs.fed.us/library/brochures/docs/2012/ForestFacts_1952-2012_English.pdf

Oswalt, S., Smith, B., Miles, P., & Pugh, S. (2018). *Forest Resources of the United States, 2017: A Technical Document Supporting the Forest Service 2020 update of the RPA Assessment* (United States, USDA, Forest Service). Washington DC: USDA. Retrieved November 18, 2018, from https://www.fia.fs.fed.us/program-features/rpa/docs/2017RPAFIATABLESFINAL_050918.pdf

Plate, R., Monroe, M., & Oxarat, A. (2010). Public Perceptions of Using Woody Biomass as a Renewable Energy Source. *Journal of Extension, 48*(3), 1-15.

Reynolds, R. V. & Pierson, A. H. (1942). Fuel Wood Use in the United States: 1630-1930. Washington, DC: U.S. Department of Agriculture.

Rignot, E., Velicogna, I., Broeke, M. R. V. D., Monaghan, A., & Lenaerts, J. T. M. (2011). Acceleration of the contribution of the Greenland and Antarctic ice sheets to sea level rise. *Geophysical Research Letters, 38*(5).

Röder, M., Whittaker, C., & Thornley, P. (2015). How certain are greenhouse gas reductions from bioenergy? Life cycle assessment and uncertainty analysis of wood pellet-to-electricity supply chains from forest residues. *Biomass and Bioenergy, 79*, 50-63.

Roubanis, N., Dahlstrom, C., & Noizette, P. (2010). Renewable energy Statistics. *Eurostat: Statistics in Focus, 56*, 1-6.

Scaife, A., Folland, C., & Mitchell, J. (2008). Predicting global warming. *The Chemical*.

Schleussner, C.-F., Lissner, T. K., Fischer, E. M., Wohland, J., Perrette, M., Golly, A., Schaeffer, M. (2015). Differential climate impacts for policy-relevant limits to global warming: the case of 1.5 °C and 2 °C. *Earth System Dynamics Discussions*, *6*(2), 2447–2505.

Sjølie, H. & Solberg, B. (2011). Greenhouse gas emission impacts of use of Norwegian wood pellets: a sensitivity analysis. *Environmental Science & Policy*, *14*, (8), 1028-1040.

Song, N., Aguilar, F. X., Shifley, S. R., & Goerndt, M. E. (2012). Analysis of US residential wood energy consumption: 1967–2009. *Energy Economics, 34*(6), 2116-2124.

South Carolina Department of Commerce. (2019). Incentives. Retrieved June 6, 2019, from https://www.sccommerce.com/incentives

Spelter, H., & Toth, D. (2009). North America's wood pellet sector. (Research Paper No. 656). Madison, WI: US Department of Agriculture, Forest Service, Forest Products Laboratory. Stubbs, M. (2011). *Biomass Crop Assistance Program (BCAP): Status and Issues* (Rep.No. 7-5700). Washington D.C.: Congressional Research Service. Retrieved April 4, 2019, from https://fas.org/sgp/crs/misc/R41296.pdf

Stedman, R. C., Jacquet, J. B., Filteau, M. R., Willits, F. K., Brasier, K. J., & Mclaughlin, D. K. (2012). Environmental Reviews and Case Studies: Marcellus Shale Gas Development and New Boomtown Research: Views of New York and Pennsylvania Residents. *Environmental Practice, 14*(4), 382-393.

Steiner, G. (1971). *Business and society*. New York: Random House.

Strauss, W. (2017a). A Short Update on the Japanese Industrial Wood Pellet Markets: Policies, and how they will drive current and future demand. Bethel, ME: Future Metrics.

Strauss, W. (2017b). *Overview of Global Pellet Markets and Micro-Scale Pellet-Fueled Combined Heat and Power: A new distributed power solution for the smart grid of the future* [PPT]. Bethel, ME: Future Metrics. Retrieved March 15, 2019, from http://growsmartmaine.org/wp-content/uploads/2017/02/Strauss_FutureMetrics_ForestEconomy_3-24-17.pdf

Theodori, G., & Jackson-Smith, D. (2010). Public Perception of the Oil and Gas Industry: The Good, the Bad, and the Ugly.

Thrän, D, Peetz, D, & Schaubach, K. (2017). *Global Wood Pellet Industry and Trade Study 2017.* Paris: IEA Bioenergy Task 40.

Thrän, D., Schaubach, K., Peetz, D., Junginger, M., Mai-Moulin, T., Schipfer, F., Lamers, P. (2019). The dynamics of the global wood pellet markets and trade - key regions, developments and impact factors. *Biofuels, Bioproducts and Biorefining, 13*, 267-280.

Tonnies, F. (1887). *Community and Society*. Leipzig, Germany: Fues's Publishing House.

United Nations. (1992). United Nations Framework Convention on Climate Change. New York: United Nations, General Assembly.

UK, DETR. (2000). *Climate Change: The UK Programme*. London: Eland House.

UK Parliament. (2008). *Climate Change Act of 2008. London*: The Stationery Office Limited. Retrieved February 17, 2019, from http://www.legislation.gov.uk/ukpga/2008/27/contents

UK Parliament. (2015). *Renewables Obligation Order 2015. London:* The Stationary Office Limited. Retrieved February 27, 2019, from http://www.legislation.gov.uk/uksi/2015/1947/introduction/made

UK Department for Business, Energy, and Industrial Strategy (BEIS). (2019, January 11). *Policy Paper: Contracts for Difference*. Retrieved February 27, 2019, from https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference

UNFCCC. (1997). Kyoto Protocol to the United nations Framework Convention on Climate *Change*. Kyoto: Third Conference of Parties.

UNFCCC. (2019a). The Doha Amendment. Retrieved February 8, 2019, from https://unfccc.int/process/the-kyoto-protocol/the-doha-amendment

UNFCCC. (2019b). Paris Agreement - Status of Ratification. Retrieved February 11, 2019, from https://unfccc.int/process/the-paris-agreement/status-of-ratification

US Census Bureau. (2019). Rural America. Retrieved August 13, 2019, from https://gis-portal.data.census.gov/arcgis/apps/MapSeries/index.html?appid=7a41374f6b03456e9d138cb014711e01

US Department of State. (2017). Communication Regarding Intent to Withdraw from Paris Agreement. Retrieved February 11, 2019, from https://www.state.gov/r/pa/prs/ps/2017/08/273050.htm

US Energy Information Administration (EIA). (2018). *Direct Federal Financial Interventions and Subsidies in Energy in Fiscal Year 2016*(Rep.). Washington D.C.: US Department of Energy. Retrieved April 3, 2019, from https://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf

Van Putten, I. E., Cvitanovic, C., Fulton, E., Lacey, J., & Kelly, R. (2018). The emergence of social licence necessitates reforms in environmental regulation. *Ecology and Society 23*(3), 24.

Ventura, J., & Jauregui, K. (2017). Business-Community Relationships for Extractive Industries: A Case Study in Peru. *BAR - Brazilian Administration Review, 14*(2), 1-24.

Virginia Economic Development Partnership. (2019). Incentives. Retrieved June 6, 2019, from https://www.vedp.org/incentives

Walker, S. (2018). Pellet markets Soar in 2018- a year-end review and outlook. Bethel, ME: FutureMetrics.

Walker, S., Strauss, W., Swaan, J., & Schmidt, L. (2018). *North American Pellet Market Quarterly* (1st ed., Vol. 1, Quarterly Report). Bethel, ME: FutureMetrics.

Wang, W., Dwivedi, P., Abt, R., & Khanna, M. (2015). Carbon savings with transatlantic trade in pellets: Accounting for market-driven effects. *Environmental Research Letters, 10*(11).

White, J. H. (1979). A History of the American Locomotive: Its Development 1830-1880. New York, NY: Courier Dover Publications.

Wiens J. J. (2016). Climate-Related Local Extinctions Are Already Widespread among Plant and Animal Species. *PLoS biology, 14*(12), e2001104.

Winser, A., Musil, R. K., Tiwari, S., Sung, S., & McAuliff, W. (2019). *Clear Cut: Wood Pellet* Production, the Destruction of Forests, and the Case for Environmental Justice (Rep.). Bethesda, MD: Rachel Carson Council.

Wolsink, M. (2000). Wind power and the NIMBY-myth: Institutional capacity and the limited significance of public support. *Renewable Energy, 21*(1), 49-64.

World Climate Programme. (1986). Report of the International Conference on the Assessment of the Role of Carbon Dioxide and other greenhouse Gasses in Climate Variations and Associated Impact. (Report No. 661). Villach, Austria: World Meteorological Organization.

World Meteorological Organization (WMO). (1979). *Proceedings of the World Climate Conference*. (Report No. 537). Geneva.

World Meteorological Organization (WMO). (1989). *The Changing Atmosphere: Implications for Global Security*. (Report No. 710). Geneva.

World Meteorological Organization (WMO). (2019, August 9). July matched, and maybe broke, the record for the hottest month since analysis began. Retrieved August 30, 2019, from https://public.wmo.int/en/media/news/july-matched-and-maybe-broke-record-hottest-month-analysis-began

Xie, Y., Weng, Q., & Fu, P. (2019). Temporal variations of artificial nighttime lights and their implications for urbanization in the conterminous United States, 2013–2017. *Remote Sensing of Environment, 225*, 160-174.

Xu, Z., & Xu, Y.J. (2018). Assessing effectiveness of long-term forestry beast management practices on stream water quality at a basin scale-a case study in Southern USA. *Environmental Monitoring and Assessment, 190*(3), 108.

Zillman, J. (2009). A history of climate change. *WMO Bulletin, 58*(3), 141-150.

VITA

Mason Thomas LeBlanc graduated from Louisiana State University with a Bachelor of Science degree in Forest Resources Management on May 2018 with cum laude honors. Following graduation, he began the pursuit of a Master of Science degree in Forest Products, concentrating on marketing and business development under Dr. Richard Vlosky at Louisiana State University. He anticipates graduating with his M.S. degree in December 2019 and will begin a career within the US forest products sector, specializing in business planning and development.