THE WILLINGNESS OF NON-INDUSTRIAL PRIVATE FOREST LANDOWNERS TO SUPPLY WOOD BIOMASS FOR A PROSPECTIVE WOOD-BASED BIOENERGY INDUSTRY: A CASE STUDY FROM LEE COUNTY, ALABAMA

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Ana Luiza de Campos Paula, daugher of Joao Antonio Martini Paula and Mecia Isabel de Campos, and sister of Renato de Campos Martini Paula, was born April 13, 1979, in the city of Pouso Alegre, Brazil. She spent her childhood and adolescence in the city of Campinas, graduating from Colegio Objetivo High School in 1997. She then entered University of Sao Paulo in 1998, graduating in 2003 with a Bachelor of Science degree in Forest Engineering, and a ‘Licenciatura’ (B.Ed.) degree in Agricultural Education. She worked as urban forester and environmental consultant while pursuing a post graduate degree in Environmental Management. After receiving the degree in 2005, she came to the U.S. to work for a year as research technician at the Southern Forest Nursery Management Cooperative, Auburn University. In the spring of 2007 she entered Auburn’s graduate program in Rural Sociology.

THESIS ABSTRACT

THE WILLINGNESS OF NON-INDUSTRIAL PRIVATE FOREST LANDOWNERS TO SUPPLY WOOD BIOMASS FOR A PROSPECTIVE WOOD-BASED BIOENERGY INDUSTRY: A CASE STUDY FROM LEE COUNTY, ALABAMA

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A key factor determining the potential for development of bioenergy industries is the availability of feedstock. Despite the abundant presence of wood biomass in highly forested regions such as the U. S. South, the availability of this resource as feedstock for a new industry is an important question. This is because most of the Southern forestlands are in the hands of non-industrial private forest (NIPF) landowners whose management objectives are varied.

In Lee County, Alabama, NIPF landowners are the most potential suppliers of wood biomass energy feedstock. The county's forest profile reflects that of the state as a

whole, with 70% of its area covered by forest and 83% of this land owned by non-incorporated individuals and/or families. The purpose of this study was to evaluate the conditions under which these landowners would be willing to supply feedstock for a prospective local wood-based bioenergy industry.

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1. INTRODUCTION

1.1. BIOENERGY

The majority of the world's energy supply comes from fossil fuels such as coal, oil, and natural gas (OECD 2003). In recent years considerable attention has been paid to alternative sources of energy out of concern that fossil fuels may contribute to global climate change and are finite in quantity (OECD 2003). Fossil fuels are nonrenewable sources of energy, or non-replaceable in a short period of time.

Biomass is one of the many alternatives able to substitute for nonrenewable sources of energy such as fossil fuels. The United Nations has defined biomass as "non-fossilized and biodegradable organic materials originating from plants, animals and microorganisms, also including the products descendant from the decomposition of these materials" (UNFCCC 2006:1). Bioenergy, or energy that comes from biomass, is considered not only renewable if the biomass utilized in its production is constantly replenished, but also 'carbon neutral' (Matthews and Robertson 2006).

Bioenergy accounts for 35% of the primary energy consumption in developing countries, compared to just 3% in developed countries (Balat 2006). But this is expected to change since many countries, especially developed ones, have been investing in new technologies able to efficiently produce energy from biomass (Schlamadinger, Robertson and Woess-Gallasch 2006). According to the U.S. Biomass Research and DevelopmentAct of 2000, bioenergy production and trade may generate economic growth, especially in rural areas. In addition, bioenergy could contribute to decentralization of energy production-consumption systems, favoring not only national but also local energy self-reliance (Sardella 2005). However, many countries and/or regions do not have capacity to supply their internal energy demands, and akin to the case of fossil fuels, trade of biomass and biofuels has been and may continue to occur (Falkelius 2006).

Bioenergy production is not free from negative consequences. For instance, increased production of biofuels from energy crops changed land use patterns, in some cases causing deforestation, biodiversity loses, or substitution of food crops by energy crops (Monbiot 2005). In addition to land use changes, energy crops might not be considered environmentally ‘friendly’ if the crops are heavily dependent on inputs such as synthetic agrochemicals, diesel-based machinery, or if the crops cause soil degradation, water pollution, or other environmental problems. According to Pimentel and Patzec (2005), corn crops, the main supply of bioethanol feedstock in the United States, utilize more herbicides, insecticides, and nitrogen fertilizer, and contribute to more soil degradation than any other crop produced in the country. The same authors argue that ethanol production from corn might contribute to air and water pollution, and the amount of energy consumed in this fuel production is so high that its net energy balance, as well as its carbon net balance (due to utilization of fossil-fuels in the whole corn-ethanol process) might be jeopardized (Pimentel and Patzec 2005).

1.2. WOOD BIOMASS, WOOD-BASED BIOENERGY, AND THEIR ADVANTAGES

Wood has been utilized for energy purposes since the discovery of fire; however, just recently new technologies have enabled its utilization in more efficient ways (Simioni 2006). Basically composed by cellulose, hemi-cellulose, and lignin, wood and its secondary products can be converted into energy for electricity, heating, transportation fuels, among other purposes, and such energy can be produced at small, medium, and large scales (Zerbe 2006).

Wood biomass has been described as a 'close to perfect' bioenergy feedstock. Wood residues and wastes, as well as wood coming from energy crops, are not expected to compete directly with food supply (Nonhebel 2007).Tree plantations also do not require inputs (e.g., agrochemicals) as much as some other energy crops (e.g., corn crops) (Matthews and Robertson 2006). In fact, management of forestlands for production of wood biomass is said to contribute to increased forest health since this activity could decrease the risks of forest diseases as well as forest wildfires (Gan and Mayfield 2007). However, this last argument is controversial given that the removal of wood biomass could also negatively affect forest soils as well as forest wildlife habitats (Matthews and Robertson 2006).

A good aspect of wood-based bioenergy is related to its ability to utilize practically every wood feedstock material including wood logs, saw dust, wood chips, as well as small diameter and damaged and/or low value trees (Foster and Mayfield 2007). These are important qualities that allow wood-based bioenergy to contribute to diversification of forest product markets. Also not only the wood biomass suppliers, but the environment, and the forests all could benefit from wood-based bioenergy production.

The difficult and expensive transportation of wood biomass materials, although considered a limitation for wood-based bioenergy development (Kizhakkepurakkal 2008), could actually be understood as an opportunity for localized production and consumption of energy. This is a fact that could contribute to communities' economies, as well as communities' self-reliance on energy (Sardella 2005).

1.3. WOOD-BASED BIOENERGY IN THE U.S: HISTORY AND PERSPECTIVES

Throughout history, wood was the dominant energy source in the world until the Industrial Revolution period when fossil fuels took its place (Simioni 2006). Currently wood represents only 7% of the world's energy supply, 77% of which is consumed by developing countries (Food and Agriculture Organization 2006).

Wood was the major fuel source in the US, reaching its peak during the 1870's, but decreasing in importance due to increased consumption of fossil fuels (Hazel and Bardon 2008). During the energy crisis of the 1970's wood became more utilized around the country, and by that time many forest product industries became self sufficient in energy by the utilization of wood biomass feedstock (Hazel and Bardon 2008). In 1991 wood biomass generated 49%, 17%, 31%, 2.5% and 0.5% of the energy utilized by pulp and paper industry, lumber industry, residential heating, other commercial and industry plants, and public utilities, respectively (Hazel and Bardon 2008). Presently only 1.8% of the country's consumed energy comes from wood; however, it represents 70% of the consumed energy coming from biomass, and 30% of the consumed energy coming from renewable sources (Energy Information Administration 2006). Nevertheless, increased interest in renewable energy sources, as well as new technologies able to efficiently produce different forms of energy from wood (Zerbe 2006), has encouraged wood-based bioenergy utilization not only in the U.S., but also around the world.

Recently federal legislation has demanded increased utilization of renewable energy sources, including wood-based bioenergy. The Energy Independence and Security Act of 2007, for example, mandated a supply of 0.1 billion gallons of ethanol or other fuels coming from cellulose, hemi-cellulose or lignin by the year of 2010, with a supply of 16 billion gallons by the year of 2022. It is expected that much of this ethanol will come from wood, especially in regions where wood biomass is already existent in large scale (e.g., Alabama). The Community and Wood Energy Program, part of the U.S. Food, Conservation and Energy Act of 2008, favors small-scale energy production systems by encouraging utilization of local wood feedstock for generation of energy in public facilities. In addition, the Renewable Electricity Standard (RES), part of the proposed American Clean Energy and Security Act of 2009, requires all of states to produce 10-15% of their electricity from renewable energy sources by 2020. In places like Alabama, where solar, wind, and geothermal power are limited, and since hydroelectric and nuclear power are not considered renewable options for the proposed legislation, the solution would be the production of electricity from biomass, including wood (Bachus et al. 2009; Brown 2009).

It is important to note that bioenergy production impacts current and future economies, societies, and environments. Since potential benefits and pitfalls are perceived differently by different actors, developers and decision makers are faced with complex and competing interests. For example, Congressmen Bachus et al. (2009) oppose the proposed Renewable Electricity Standard, arguing that this legislation would increase bioenergy demands while rising biomass prices. According to them, not only electricity utilities such as the Alabama Power could be harmed by the RES approval (e.g., price of biomass may be higher than coal - current feedstock utilized in electricity production), but also those industries currently dependent on biomass (e.g., paper mills). On the other hand, increased bioenergy demand may generate new 'green' markets and jobs, while higher biomass prices could economically benefit biomass suppliers, such as farmers and forest landowners.

1.4. WOOD BIOMASS AVAILABILITY

Sources of wood biomass include residues coming from wood processing facilities, residues coming from forestry harvesting and thinning activities, urban residues coming from pruning activities and construction wastes, trees damaged by natural disasters, diseased or dying trees, and short rotation wood crops (Foster, Gan and Mayfield 2007). Jackson (2007) argues that significant amounts of underused wood biomass might be available within the 749 million acres of forestland existent in the U.S. Zerbe (2006) concluded that the country could generate 10% of its energy demand from wood if good forestry practices were applied and wood residues were utilized. In the U.S., the majority of the wood residues coming from wood processing facilities are expected to be already in use, although residues coming from urban areas, as well as the ones coming from forestry harvesting and thinning activities, are still not highly used (Langholtz et al. 2007). Fast growing wood energy crops probably have the greatest potential source of wood biomass in the country (Langholtz et al. 2007), and according to Egan (2009), in addition to wood residues, these crops might be necessary for supplying prospective U.S. wood energy markets.

It is important to note that a large part of the wood biomass energy feedstock supply is expected to come from forestlands. Since the majority of U.S. forests are in the hands of the private sector (Forest Landowners Association 2009), wood biomass feedstock supply might depend on the willingness of private landowners. According to Gan and Mayfield (2007), private forest landowners are the main suppliers of wood biomass in the U.S. In regions such as the South, where the majority of the forestland is owned by NIPF (non-industrial private forest) landowners (Birch 1997), supply of wood biomass for energy purposes might depend on the willingness of these landowners. NIPF landowners were defined by Bliss (1993) as private forest owners who do not own or operate wood processing facilities, including a variety of individuals, family and non-family partnerships, and even corporations. According to Birch (1997), these landowners own their forestland for different reasons, and they might not be willing to harvest forest products from it.

1.5. STUDY LOCATION

Alabama is the second most heavily forested State in the U.S. Southern region (Langholtz et al. 2007a). Proportional to the state as a whole, Lee County has 70% of its area covered by forest, 98% of which is privately owned, and 83% of which is owned by NIPF landowners (Hartsell and Brown 2002). In addition, the county is located within the transition of the Coastal Plain (which corresponds to two thirds of Alabama's state coverage) and the Appalachian Piedmont (the second largest vegetation formation within the State) (Copeland, 1968). These facts make Lee County representative of the diverse conditions found in Alabama.

Lee County could supply a large part of its energy demand by the use of wood biomass (Langholtz et al. 2007a). The county has a total population of 130,516 people (US Census Bureau 2007), including the cities of Auburn, Loachapoka, Notasulga, Opelika, Phenix City, Smiths Station, Waverly, and the unincorporated communities of Beauregard, Beulah, Gold Hill, Marvyn, Roxana and Salem, with a total area of 609 square miles (Lee County Online 2008). According to Landholtz et al. (2007a), Lee County is experiencing moderate to heavy population growth, a factor that contributes to an increased demand for energy (Langholtz et al. 2007a).

Lee County could start generating its own energy from wood biomass if owners of this feedstock were willing to make it available. According to Milbrandt (2005), the county generates more biomass per year (above 500,000 tons) and more biomass per square kilometer (above 250 tons/ sqkm/ year) than any other Alabama County. However, this estimation includes not only wood, but also dedicated annual energy crops, agricultural residues, and municipal discards (e.g., methane emissions from landfills and sewage).

The total wood biomass supposedly available for energy purposes in Lee County was estimated by Langholtz et al. (2007a). The authors argue that the county could generate, per year, an amount 15,000 green tons of urban wood wastes, 48,000 green tons of logging residues, and 156,000 green tons of small diameter trees. This estimate, based on existence of wood biomass (physical availability) and economic factors, excluded secondary wood wastes from mills (which were thought to be already in use by industrial processes), as well as wood residues coming from site thinning activities (due to difficulties in measuring this factor).

1.6. PURPOSE OF THE STUDY

Development of wood-based bioenergy industry depends on the local availability of wood biomass. NIPF landowners own the majority of Lee County forestland, and this population is expected to contribute to most of the wood biomass necessary for the development of a local wood-based bioenergy industry. However, NIPF landowners own their forestland for diverse reasons.

The present study intended to address the following questions:

1. How many Lee County NIPF landowners are willing to supply wood biomass for a prospective wood-based bioenergy industry?
2. How much forestland owned by Lee County NIPF landowners is available for production of wood biomass energy feedstock?
3. What factors influence Lee County NIPF landowners in their decision to supply wood biomass energy feedstock for a prospective wood-based bioenergy industry?
4. Who are the Lee County NIPF landowners most willing to supply wood biomass energy feedstock for a prospective local wood based bioenergy industry?
5. What factors may restrain Lee County NIPF from participating in a prospective wood-based bioenergy industry?

In addition to answering these questions, a workable definition of sustainable development in the context of local wood-based bioenergy production was developed utilizing appropriate literature review. This is because development of a local wood-based bioenergy industry may have social and environmental consequences, positive and/or negative ones, at local or larger spatial scales. Development of a local wood-based bioenergy industry may also contribute to economic growth, but distribution of benefits could be quite variable.

2. CONCEPTUAL FRAMEWORK

2.1. THEORETICAL PERSPECTIVES

2.1.1. *Sustainable Development and Bioenergy*

The normative concept of development involves "a set of goals and processes that are (or are thought to be) positively related to individual and social well being" (Galston and Baehler 1995: 23). Development is not easy, according to Galston and Baehler (1995) because it means change in the status quo, going against those who are satisfied with the way things are. At the same time, there are debates on how development should be addressed: for some development is a goal, while for others it is a continuous process; development can focus on people in general, but also on people from specific places or localities; development can also be based on external expert assistance, or self-assistance (Green and Haines 2002). There is no one right formula on how to plan and apply development.

Green and Haines (2002) argue that growth and development are different things: growth means an increased quantity of a specific fact (e.g., job, income, population, etc.) or its quality (e.g., better jobs, secure sources of income, etc.), while development represents structural societal changes (e.g., change in how resources are used or distributed, changes in the way institutions work, etc.). They argue that when growth is referred as a goal, it is usually called development; however, growth may not lead to a particular conception of development (Green and Haines 2002). Growth has potential implications on social, economic, and environmental well being. For example, economic growth can lead to increased population wealth, though few would agree that wealth concentrated in the hands of a small group of people constitutes a positive form of development. Some forms of growth lead to pollution or depletion of natural resources that could affect the well-being of not just current but also future populations (Green and Haines 2002). Here again, growth can be distinguished from development.

As suggested by Gillis and Vincent (2000), initial concerns about growth limitations culminated in sustainable development approaches in which growth, as a form of development, would still be accepted if practiced in sensitive ways (or in ways that would benefit peoples' well-being over time). In the early 1980's, sustainability became part of mainstream thought, and the first and still most recognized definition of sustainable development was brought by the Brundland Report of 1987 as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Green and Haines 2002:189). Sustainable development would than take into consideration environmental, economic, and social aspects of development potentially able to affect a population's well being. However, according to Buchholtz et al. (2007), the multiple perspectives concerning sustainable development brought uncertainties about its practical use. For instance, some authors argue that spatial and temporal scales of sustainability ('where', for 'whom' and 'for how long' it is possible) are important issues (Buchholtz et al. 2007). At the same time, the three basic dimensions of sustainability (social, economic, and environmental) are difficult to integrate in a balanced fashion (e.g., Buchholtz et al. 2007). Recognizing that it is difficult to address the needs of current generations, imagine how difficult it is to address the needs of future generations, especially because we do not know what their needs will be (Buchholtz et al. 2007).

Green and Haines (2002) argue that the difficult achievement of sustainability at a global level brought attention to more localized strategies of sustainable development, perfectly captured in the phrase 'think globally, act locally' (Green and Haines 2002). On the Earth Summit of 1992, participant countries agreed to implement the famous Agenda 21 - a mechanism for the achievement of a 'sustainable world' by the implementation of sustainable development plans at the national and local levels (Green and Haines 2002). In the U.S., Agenda 21 is mainly planned and implemented by the Environmental Protection Agency (EPA), the Department of Energy (DOE), and the Council on Sustainable Development (Green and Haines 2002). However, the country has encouraged local communities to "integrate programs of economic development, environmental protection, and social well-being through community partnerships, education efforts, and voluntary action" (Green and Haines 2002:190).

According to Green and Haines (2002: 6) sustainable development is easily achieved at the local level "where relationships between economic development, the environment, and social needs are most visible" and where local actions can be more effective at addressing problems. The authors suggest that community development mechanisms which emphasize the use of their own capacities in an integrative and rational way (development based on asset building approach) may be empowered, achieving self-sufficiency, while improving the quality of life of their residents in a sustainable way (Green and Haines 2002). Similarly, Shuman (1998) argues that a sustainable community is a self-reliant community. The self-reliant community does not seek to prohibit resources, people, or goods from entering or leaving the community; instead, such a community seeks to minimize its dependence on others (e.g., dependence on external resources including even external decision making) while solving their challenges and retaining externalities within the community as far as it is practicable (Shuman 1998). The rationale for local communities to become self-reliant is:

> Produce what you need using your own resources, internalizing the challenges this involves, growing with the challenges, neither giving the most challenging tasks (positive externalities) to somebody else on whom you become dependent, nor exporting negative externalities to somebody else to whom you do damage and who may become dependent on you…. The justification for doing so is clear: we will enjoy the positive externalities, rather than giving them away, and at the same time will be responsible ourselves for the negative externalities…. We can fight the negative consequences ourselves, the distance between cause and effect being a short one (John Galtung in Shuman 1998: 47).

By the use of the asset building approach, communities could minimize their dependence on external resources, achieving self-sufficiency while creating better marketing systems able to satisfy communities' local needs (Green and Haines 2002). In an asset building approach, communities build on their own capacities, including their different forms of capital. Considering that natural resources, such as biomass, are a form of environmental or natural capital able to generate energy on a renewable basis, communities could build their energy independency by use of their own biomass availability.

Nonrenewable sources of energy have been leading to discussions on how future generations could benefit from their unavoidable depletion. Although contradicted, some argue that financial capital coming from non-renewable energy markets could possibly benefit future generations (e.g., schools and hospitals could be built, etc.). Bioenergy can be constantly replenished under certain conditions (e.g., under certain climate and silvicultural/agricultural practices). In this way, bioenergy could not only generate energy for current and future generations, but also economic wealth. According to Sardella (2005: 9) “strategic and appropriate bioenergy projects that emphasize high efficiency and local economic benefits can serve as models of sustainability for communities seeking to protect and improve the quality of life for their citizens now and in the future.”

Bioenergy is expected to contribute to environmental benefits at the local (e.g., use of residues that otherwise would go to landfills, better land management practices, etc.) and even global level (e.g., addressing global climate change issues). From an economic perspective, as suggested by Shuman (1998), communities can strengthen their economies by ‘going local’ and building on their internal strengths. By going local, local capital would be kept within communities for productive purposes. We can note that around the world different countries and regions have been importing energy for meeting their internal demands. For example, just as the U.S. has imported large amounts of energy from other countries, so too different regions within the country have imported a large part of their energy demands from other regions. In Alabama, a large part of the oil consumed comes from Texas and Louisiana, while a large part of the coal consumed comes from Wyoming and Kentucky (Jones 2008). By producing local energy, financial capital could be retained within communities supporting local jobs and small businesses.

In addition, decreased imports of energy could also diminish the amounts of energy utilized in energy transportation from region to region. Finally, local production and utilization of bioenergy, especially if based on small-scale and easily accessible energy production systems, could lead to major structural changes in traditional centralized, large-scale, non-renewable and costly energy production systems.

It is important to note that bioenergy is difficult to be produced sustainably, even at the local level. For instance, development of a local wood-based bioenergy industry will generate diverse social, environmental, and economic consequences (positive and negative). For example, how could wood biomass energy feedstock be harvested from forests without causing any negative long-term consequence on soil or wildlife habitat? If forest plantations (especially monocultures and genetically modified ones) are utilized for supplying the local energy industry, could they be considered environmentally sustainable? Would a prospective local wood-based bioenergy industry affect other local wood markets? If economic growth is a consequence of the local energy industry, would this benefit be equally distributed within the local community? Who would own the wood-based energy facilities? Would every forest landowner benefit from this new wood market? The answers for these and other questions should be considered in sustainable development initiatives concerning local wood based bioenergy production, not forgetting that in addition to the local consequences of this kind of system, consequences at a greater spatial level, and consequences to future generations, might also exist.

In summary, sustainability is important but difficult to define. Nevertheless, it seems to be most appropriately utilized at the local level, where environmental, social, and economic aspects of communities can most easily be evaluated.

2.1.2. Ecological Modernization and Bioenergy

Hannigan (2006) says ecological modernization theory, in the view of their founders Spaargaren and Mol, means nothing more than the use of “new, sophisticated, clean technologies” (p. 25) for dealing with environmental problems of the modern world without leaving the paths of modernization and growth. According to the authors, ecological modernization seeks the maintenance of current industrial structures, as well as the maintenance of existing large-scale production-consumption systems associated with capitalist systems (Hannigan 2006).

As suggested by Huttunen (2008), bioenergy discourses could be viewed in the perspective of ecological modernization theory in which new technologies for production of efficient biofuels may help overcome environmental limitations of current energetic systems which are dependent on non-renewable energy sources, while maintaining existing energy production-consumption chains and infrastructures. However, Gibbs (1998:5), based on Hajer’s ideas, says that ecological modernization can be interpreted in two different ways: the first is a “techno-corporatist interpretation which emphasizes the economization of nature and elitist decision-making structures,” and the second is “close to some versions of sustainability, which not only stresses changes to production and consumption, but do so through greater democratization, redistribution and social justice.” This second interpretation of ecological modernization, called reflexive or strong ecological modernization, has been criticized for being not related to the original idea, but more related to the sustainable development approach (Huttunen 2008). Nevertheless, these two different ecological modernization interpretations help us understand different bioenergy discourses that question whether the contribution of bioenergy is simply to support current energy consumption-production structures, or is a driver of fundamental social and structural changes.

Huttunen (2008) argues that environmental discourses often are used to support incentives for bioenergy production, reflecting the mainstream status of environmentalism. Hajer (1995:14) mentions that “talking green no longer connotes a radical social critique.” As suggested by Hannigan (2006), ‘greener growth’ promoted by the use of technological innovations is possible, although this growth may not only be ‘ideological free’ but also promoted by industry actors who would not favor major social and structural changes. For example, bioenergy ‘green’ discourses are present on mass communication systems such as televisions and newspapers, and many times these discourses have been promoted by larger automobile corporations, as well as by larger fuel distributors and producers. The question is whether these discourses would favor environmental stewardship while addressing social justice issues. Is it possible to protect the environment while keeping energy consumption-production structures as they are? Is it possible to address social justice while maintaining energy industry ownership patterns as they are?

2.2. CONCEPTUAL MODEL

2.2.1. Theory of Land Use Decision Making

Private forest landowners control over 70% of the total Southern timberland, playing an important role in timber supply (Arano and Munn 2006). According to the Pinchot Institute for Conservation (2007), private forest landowners are expected to contribute 80% of the wood energy feedstock in the U.S.; however, few studies regarding this population' willingness to supply wood biomass for a prospective wood-based bioenergy industry have been completed.

Private forest landowners are a diverse population that includes industrial forest owners, non-industrial private forest (NIPF) landowners, and timberland investment management organizations (TIMO) (Arano and Munn 2006). Each group varies in their forest management objectives, which in turn affects forest management intensity and harvesting decisions (Arano and Munn 2006). For example, industrial forest and TIMO landowners manage their forestland almost exclusively for timber production, while NIPF landowners might be interested in retaining and managing their land for reasons other than timber production such as recreation, wildlife preservation, among others (Arano and Munn 2006). For the purpose of this study only non-industrial private individuals or family foresters were considered. Family foresters were defined by Butler and Leatherberry (2004) as individuals, couples, family estates and trusts, or other groups of individuals who are not incorporated or associated as a legal entity, and their reasons for owning forestland might be even more diverse and less related to generation of income than the general NIPF landowners' reasons. Family foresters own 42% of the US forestland and 59% of the Southern forestland; however, family forest landowners have declined their interest in forest management practices and timber production over time, which could represent a constraint for both forest health maintenance and supply of timber products (Butler and Leatherberry 2004).

Koontz (2001) argues that empirical studies regarding landowners' attitudes and motivations can provide the foundation for a theory of land use decision making. NIPF landowners' motivations and attitudes toward their forestland have been much studied in the U.S. by the use of both surveys and qualitative methods (Bliss and Martin 1989; Butler and Leatherberry 2004). According to Bliss and Martin (1989), NIPF landowners are influenced by external and internal factors (or motivations) when making decision about their forestland. As described by the authors, internal motivations include forest landowners' personal identity (including ethnicity, gender, education, occupation, age, historical background, etc.), as well as the values given by them to their forestland (the importance of the forestland for the environment, income generation, recreation, etc.), while external motivations include available land use opportunities, available forestry incentive programs, technical assistance, tax breaks, among others. Similarly, Koontz (2001) divides landowners motivations into financial (e.g. income generated from land-related activities) and non-financial ones (e.g. aesthetic enjoyment, environmental stewardship, history, etc.). Emtage et al. (2007) argue that landowners have economic, personal (or lifestyle), and conservational motivations for owning and managing their lands. Emtage et al. (2007) also suggest that landowners' typology studies provide a range of landowners' characteristics useful for rural development programs. Since each landowner is unique, having their own values, needs, and behaviors, it is impossible for developers and policy makers to address programs or policies that could generally benefit landowners' population without a generalized picture of these landowners (Emtage et al. 2007). The generalized picture of landowners' population can be produced by grouping landowners' shared characteristics such as the inter-related socio-demographic characteristics, landowners' values toward the land, and landowners' land management behaviors (Emtage et al. 2007).

A survey conducted by Butler and Leatherberry (2004) demonstrated that the majority of the American family foresters are well educated (65% of those in the South have attended college), relatively old (average of 60 years old in the South), and live close to their forestland (70% in the US, only 30% in the South). Family foresters who own less than 50 acres of forestland account for 90% of all family foresters (only 50% in the South), although family foresters who own more than 50 acres of forestland hold 69% of the total family foresters' land (only 25% in the South) (Butler and Leatherberry 2004). In the South, the most common reasons for family foresters to own their forestland are family estate, aesthetic reasons, and land investment; 45% of the family forests in conservational programs are located in the South; in addition, only 18% of the Southern family forest landowners have harvested their forest in the past 5 years, 16% have received management advice, while only 3% have written forest management plans (Butler and Leatherberry 2004).

It is expected that Lee County NIPF landowners' willingness to supply wood biomass for energy production would vary according to their demographic characteristics, their motivations and attitudes toward their forestland, and their motivations toward wood-based bioenergy. When considering local bioenergy production, landowners' reasons to supply energy feedstock could also be related to the benefit of the local community as a whole.

2.2.2. Benefits of a Lee County Forest Landowner Typology Study when Implementing Wood-Based Bioenergy Programs

As suggested by Bliss and Bailey (2005), forestland and forest industry ownership patterns, as well as existing social ethnic, racial, and class structures, have defined the ones who economically benefit from forest-related activities in different Alabama counties. Size of forestland owned is one of the factors favoring differentiation in the way forest landowners could benefit from the development of new forest markets. Butler and Leatherberry (2004) says that family foresters who own more forest acres are much more economically driven than the ones that own fewer acres, and it is essential to differentiate these two kinds of forest landowners when promoting forest-related activities. NIPF landowners tend to manage their forestland more intensively as the size of ownership increases (Arano and Munn 2006). Brodbeck (2005) argues that landowners who own limited forestland acres could be willing to make profit from their forestlands, but they might be limited to do it. One of the problems related to small tract sizes is the limited ability of these lands to produce timber or other forest products from it in an effective (mostly economically feasible) way (Brodbeck 2005). According to Brodbeck (2005), forest harvesting activities are difficult to arrange in tracts smaller than 50 acres and really difficult in tracts smaller than 20 acres. As a result, landowners owning less forestland are excluded from many of the available forest markets (Brodbeck 2005).

Note that forestlands in the U.S. have been suffering fragmentation, while the number of forest landowners of limited forestland sizes (especially less than 50 acres) are increasing over time (Butler and Leatherberry 2004; Brodbeck 2005). A Lee County forest landowner typology study could not only predict how much wood biomass would be available for a prospective local wood-based bioenergy industry, but also the way in which different kinds of forest landowners, including the ones of limited forestland ownership, would benefit from this new wood market.

2.2.3. Landowners' Willingness to Supply Biomass Feedstock

According to Meyers and Hinrichs (2007), interviews of Southern Iowa farmers indicated they were skeptical when asked if they thought that switchgrass energy projects would result in rural development. Although farmers recognized the potential economic benefits, they felt that most of the benefits would go to bio-refineries instead of feedstock growers (Meyers and Hinrichs 2007). In addition, farmers were concerned that the spread of these new agricultural bioeconomies, such as switchgrass energy crops, would increase farm land sizes, also decreasing rural populations instead of benefiting smaller farmers and revitalizing rural communities (Meyers and Hinrichs 2007).

Hipple and Duffy (2002) demonstrated that farmers had diverse motivations for adoption of switchgrass energy crops in Iowa. Among these was profitability as well as the potential benefits of switchgrass production to the community and the country as a whole (such as the benefit to the rural economy, to sustainability and energy self-reliance issues, as well as environmental issues). However, concerns about the profitability of small farm operators were considered an important unfavorable factor for decision making of those landowners holding limited land size (Hipple and Duffy 2002).

Another study conducted by the state of Tennessee, also analyzing the willingness of farmers to produce switchgrass for bioenergy purposes, suggested that 30 percent of the studied farmers would be willing to produce this energy feedstock if profitable (Jensen et al. 2007); however, most of the farmers were not willing to produce it because of the high risks associated with an insufficient developed market (Jensen et al 2007). The same study demonstrated that environmental benefits, such as carbon emission control, as well as erosion control and improved wildlife habitat, had a positive effect on farmers' willingness to produce switchgrass for energy purposes (Jensen et al. 2007). An interesting fact is that farmers with higher off-farm income, and also farmers with smaller farm sizes, were more willing to produce swichgrass energy feedstock (Jensen et al 2007).

Few studies have demonstrated the willingness of forest landowners in producing wood biomass for energy purposes. A study conducted by Rahmani, Hodges and Stricker (1996) on the willingness of landowners to produce energy crops in Florida (including herbaceous, sugar cane, and wood biomass crops) concluded that economic factors (such as the availability of an established market for the energy crops, as well as the high net return per acre) and familiarity with the new energy crops, were considered the most important factors influencing landowners decision to supply those materials. However, that study did not differentiate among landowners' types.

A study conducted by Lindsey and Gilbert (1991) on the willingness of NIPF landowners to harvest fuel wood in Vermont demonstrated that landowners' willingness was associated with larger forest parcel sizes (more than 100 acres), as well as the existence of a forest management plan; however, only 25% of the respondents who harvest fuel wood were willing to sell those materials (Lindsey and Gilbert 1991). According to the study, NIPF landowners harvest fuel wood (in order of importance) for personal use of fuel wood, removing dead and diseased trees, and improving the quality of the wood lot, while the reasons for not harvesting fuel wood (also in order of importance) included the impact on forest aesthetics, lack of information on how to do it, and not enough wood material/limited size of forestland (Lindsey and Gilbert 1991).

As suggested by Tharakan et al. (2005), the first barrier affecting fast growing energy willow plantation in the Northeast is the high cost associated to its production, making this activity not economically attractive and also quite risky for potential growers. Willow plantations demand considerable investments in planting and harvesting equipment. Willow biomass growers are responsible for the crops' establishment and maintenance, and wood biomass feedstock buyers tend to buy willow wood biomass from larger foresters producers, making this activity not attractive to smaller forest landowners (Tharakan et al. 2005). Although willow is only one of the potential wood energy crops (and this species is not well adapted to the southern region), it is important to investigate the constraints that forest landowners, especially the ones with limited forestland sizes, might face when deciding to supply wood biomass feedstock for a potential bioenergy industry.

Elghali et al. (2007) argue that development of bioenergy systems might face a 'chicken-or-egg' question where suppliers and purchasers are reluctant to invest in a commodity absent a functioning market. Decisions to participate in these markets, like any other market, will depend on the risks and gains associated with it (Elghali et al. 2007). According to Vogt et al. (2005), private forest landowners might not be willing to supply wood biomass for a non-existent market, or for a market that does not provide them with economic yields. However, as already suggested, private forest landowners may be interested in supplying wood biomass for diverse reasons. The present study investigates some of the reasons why non-industrial private forest landowners in Lee County would be willing to supply wood biomass for a local wood-based bioenergy industry.

3. METHODS

This study was based on a cross-sectional mail survey distributed to every individual and family NIPF landowner owning more than 20 acres of forestland in Lee County, Alabama. Incorporated NIPF owners were not included in the survey population. The survey had the purpose of evaluating how many forestland acres in Lee County may be available for the production of wood biomass energy feedstock to be utilized in a prospective local wood-based bioenergy industry. In addition, the survey had the purpose to describe those NIPF landowners willing to supply wood biomass energy feedstock for this prospective local industry, also evaluating the factors affecting their decision to supply this material.

3.1. SURVEY DESIGN AND IMPLEMENTATION

3.1.1. Designing the Instrument

Based on a review of literature, attendance at relevant forestry and bioenergy seminars, as well as non-structured face-to-face interviews with forestry and bioenergy specialists, a questionnaire containing thirty three open-ended and closed-ended questions was built. The questionnaire was divided in three different parts: 1) questions about the owned forestland, as well as the landowner's motivations and attitudes toward it; 2) landowners' knowledge about wood-based bioenergy, their perspectives about local wood-bioenergy markets, as well as their willingness to produce wood biomass for energy purposes; 3) landowner's personal information, such as age, gender, ethnicity, education, and income. Before its implementation, the questionnaire was pre-tested on small sampled landowners to assure its appropriate language and sequence of the questions. The language utilized was simple, and the questions also followed a logical sequence with the intention to control the respondents' frame of reference. The final questionnaire version was a 12 page booklet (Appendix B). Its first page included the survey title and an inviting figure; the next ten pages contained thirty three questions (divided in three already mentioned parts); and the last page had a space for commentaries and suggestions.

3.1.2. Framing the Target Population

A complete landowner list was obtained from the Lee County Revenue Office in Opelika, Alabama. The list, available in a Microsoft Excel file, contained a description of every piece of forestland existent in Lee County (forest tract sizes, locations, and names and addresses of their owners).

The original list included 4,183 different forest tracts, with a total of 226,830 acres. From this list, forest tracts smaller than 20 acres were removed, and the remaining 2,281 forest tracts included 209,388 acres (92.3% of the original list). Personal communications with forestry specialists suggested that 20 acres of forestland is the minimum tract size in which landowners could produce forest biomass in an efficient and profitable way.

Forest lands owned by public facilities, corporations, limited liability companies, and trusts were also dropped from the list, as well as repeated names and/or addresses. The final list included only forest land owned by non-industrial private individuals and/or families (including family partnerships), representing 146,508 acres of forestland (64.6%

of the original list acres), and 1,845 different forestland tracts, owned by 965 different individuals/families.

3.1.3. Data Collection

Due to the available research budget, the entire target population (N=965) could be part of the survey. Following the 'Tailored Design Method' described by Dillman (2000), the survey performed was based on four mail contacts, excluding mailing of the survey results.

- ✓ First mail contact:

The first mail contact was a pre-notice letter including basic information about the survey. The letters were mailed to all 965 prospective respondents on the first week of November 2008.

- ✓ Second mail contact:

A package containing two cover-letters, a questionnaire booklet, and a pre-stamped, pre-addressed, return envelop was mailed to the 965 prospective respondents few days after the pre-notice letter.

One of the cover-letters was a mandatory informative letter from Auburn University Institutional Review Board for Human Subject. Prospective respondents were alerted by this letter about the purpose and confidentiality of the survey, as well as its non-mandatory dimension. The other cover-letter informed prospective respondents about the importance of the survey, as well as the importance of their answers. This second letter asked respondents to write their addresses somewhere on the return envelop if they wanted to receive a copy of the survey results.

Each questionnaire was manually numbered (according to respondents' list order) for keeping track of surveys that were returned.

- ✓ Third mail contact:

Reminder post-cards were mailed to everyone that had not returned the questionnaire a week after it was mailed. Around 900 post-cards were mailed.

- ✓ Fourth mail contact:

A replacement questionnaire composed of two-cover letters, a questionnaire booklet, and a pre-stamped, pre-addressed return envelope was mailed to everyone who had not returned the first questionnaire two weeks after the reminder post-cards were mailed (first week of December 2008). Approximately 617 packages were re-mailed.

- ✓ Mailing of Summarized Results:

After the survey was closed, a summary of its results were sent to every respondent who had written their addresses, or the word 'results' on the return envelope. More than half of the respondents (191 out of 363) asked for further information about the survey, which indicates a high level of interest among Lee County forest landowners in local wood-based bioenergy production.

3.1.4. Survey Response Rate

The survey was performed during the months of November and December of 2008; although the majority of the questionnaires were returned during the same months, a few questionnaires were still received during the months of January and even into February 2009.

More than a dozen respondents have called or e-mailed us asking for further information about the survey, and most of these respondents were older individuals (of more than 70 years old). Some respondents (15) informed us that they were not willing to participate in the survey. From a total 965, we had 30 bad addresses. An additional 50 respondents said they did not own any forestland in Lee County (also considered bad addresses), leaving us with a total 885 seeable addresses. From this total, we received 363 'good replies' (returned questionnaires from respondents who said to own forestland in Lee County).

In summary, from a total of 965 mailed questionnaires, 885 were considered valid (after discounting bad addresses), and the response rate (based on 363 good replies) was 41%. The second mailed survey increased the response rate by about 11%.

3.1.5. Mini Study: Personalization

According to Dillman and Frey (1974), personalization of mail survey might increase the survey's response rate. Mail personalization includes the use of recipients' real names in letterheads instead of generalized ones, the use of senders' real signatures, and probably the use of hand-written names and addresses in envelopes. The last example is still contradictory due to its non-generalizability (Tullar et. al. 2004). Moreover, only few studies have demonstrated the effectiveness of hand-written over labeled or printed envelopes (Tullar et. al. 2004).

The envelope is the first thing respondents see when they receive a survey, and its presentation may influence whether respondents reply, or even open and read it. We hypothesized that personalization of surveys' mail envelopes (hand-written ones) would favor a better survey response rate compared to non-personalized envelops (labels), and a mini-experiment was performed. Half of all mailed envelopes had recipients' names and addresses written by hand, while the other half had recipients' information printed on labels. As a result, hand-written envelopes had a 4% higher response rate compared to those with labels, but the difference was not statistically significant according to chi-square test (for df=1, expected value for α=.05 should surpass 3.841, and expected value for α=.01 should surpass 6.635; however, observed value was1.473, and the null hypothesis was accepted).

3.1.6. Survey Validity

According to Hartsell and Brown (2002), Lee County accounts for 273,600 acres of timberland (228,000 acres owned by NIPF landowners, 39,700 owned by forest industry and 5,900 publicly owned). Our original survey list, which accounted for a total of 227,000 acres of forestland, was reasonably accurate. In addition, the amount of forestland acres held by our population (146,508 acres) was proportionally similar to the amount of forestland acres held by survey respondents (79,809 acres), indicating that the survey may be representative of this population as a whole. The survey response rate was 41%, and the amount of forestland acres held by survey respondents corresponded to 54% of the forestland acres held by total population (79,809 out of 146,508 acres). The 13% difference can be explained by few respondents (considered outliers) who owned large amounts of forestland (for example, one landowner said to own 10,000 acres).

3.1.7. Data Processing

Data were edited during and after they were collected. A codebook was created for each variable and their categories. Data coming from closed-ended questions was easily coded and entered on Microsoft Excel and SPSS files, while data coming from open-ended questions had to be first transcribed on Excel and later recoded within existent or newly created categories, according to their qualitative similarities. Before statistical analysis was conducted, data were inspected and checked for errors.

3.1.8. Data Measurement and Analysis

Few variables were measured at the interval level (e.g., the exact number of forestland acres owned by each respondent) or nominal level (e.g., respondents' ethnicity or gender), while the majority of them were measured at the ordinal level (e.g.; Likert scale); selected variables are described in table 1.

Statistical analyses included the examination of descriptive frequency distributions and cross-tabulations, non-parametric tests of significance (Pearson Chi-Square and Spearman correlation), as well as Principal Component Analysis (a form of factorial analysis). Landowners were described according to their willingness to supply wood biomass for a prospective bioenergy industry. The total number of Lee County NIPF landowners willing to supply wood biomass, and respective forestland acres available for wood biomass production in Lee County, were estimated. Based on their willingness to supply wood biomass for a prospective wood-based bioenergy industry, respondents were described according to their demographic characteristics, their motivations and attitudes toward their forestland, and their knowledge and motivations toward bioenergy. Main factors potentially affecting respondents' decision to supply wood biomass were described.

4. RESULTS

4.1. POTENTIAL WOOD BIOMASS AVAILABLE IN LEE COUNTY FOR PRODUCTION OF ENERGY

Survey results demonstrate that the majority of Lee County NIPF landowners (individuals/families) are willing to supply wood biomass for a prospective local wood-based bioenergy industry, and the amount of acreage potentially available for production of wood biomass energy feedstock is substantial. For the purpose of this survey, wood biomass was divided in two different groups: timber (healthy trees or good quality logs available in any diameter or size), and wood residues (damaged trees or thinning and harvesting remains). Table 2 shows that 61% of survey respondents are willing to supply timber for production of energy, while 73% are willing to supply wood residues. These landowners own, respectively, 84% and 88% of the total forestland acres owned by the survey respondents, and this indicates that those landowners who own more acres of forestland may be more willing to supply wood biomass. More than half of the survey respondents (55%, owning 80% of the respondents' forest acres) are willing to supply both timber and wood residues for a prospective wood-based bioenergy industry in Lee County (table 1). Those landowners willing to supply at least one form of wood biomass (timber and/or wood residues) represent 75% of the survey respondents, owning 92% of the total respondents' forestland acres (table 2). If the survey population is representative of all Lee County NIPF landowners (individuals/families), 134,787 acres of forestland may be available for production of wood biomass, what represents 49% of Lee County total timberland area described by Hartsell and Brown (2002), and 60% of the forestland described by our original forest landowner list (which includes private forestland and forestland owned by public facilities).

According to the Forest Service, timberland means land capable of growing more than 20 cubic feet of wood per acre per year (Perlack et al. 2005). In this way, those 134,787 acres of forestland available in Lee County could produce, in a sustained yield base, a minimum of 2,695,740 cubic feet of wood biomass per year, which is equivalent to 121,308,300 pounds, or 60,654 dry tons of southern yellow pine per year (READE 2006). This estimation is similar to that of Langholtz et al. (2007a), who argue that Lee County could annually produce, respectively, 48,000 and 156,000 green tons of logging residues and small diameter trees (about 102,000 dry tons of wood biomass). Remember that those NIPF landowners willing to supply wood biomass for a prospective bioenergy industry own about 60% of the total Lee Count forestland.

Wood biomass productivity depends on site conditions, management practices, and tree species. If dedicated wood crops were utilized, Lee County NIPF landowners could produce even more wood biomass. According to McClure (N.d.), dedicated slash and loblolly pine plantations produce an average of, respectively, 5.77 and 6.48 green tons of wood per acre/year, in a 24-year rotation cycle. Mercker (N.d.) argues that intensively managed loblolly pine forests can grow up to 8 dry tons per acre/year in a 20-year rotation cycle, while cottonwood (hybrid poplar) forests grow an average of 5 dry tons per acre/year in a shorter rotation cycle of 10 years. In addition, Langholtz et al. (2007b) suggests that about 15 green tons of wood biomass residues and wastes can be produced in an acre of slash pine forest when the same is harvested in a 25 years cycle. Assuming that Lee County NIPF landowners could produce 8 dry tons of yellow pine per acre/year, 1,078,296 dry tons of wood biomass could be made available by this population annually. Considering that each dry ton of wood produces 80 gallons of ethanol (McClure N.d.), 86,263,680 gallons of this fuel could be annually produced in Lee County, enough fuel for replacing the 55,260,761 gallons of gasoline annually sold within the county (State of Alabama Department of Revenue Annual Report 2007). However, keep in mind that this is a maximum estimation. Forest landowners may not be willing to produce wood biomass on a sustained yield basis; they may be even less willing to produce dedicated and intensive wood crops. Note that although intensive wood crops may be produced constantly (on a sustained yield basis), the ecological sustainability of intensive forest management practices (e.g., effects on soil fertility, water availability, etc.) still needs to be questioned.

4.2. WHO WANTS TO SUPPLY WOOD BIOMASS AND WHY

4.2.1. Factors Affecting Landowners' Decisions to Supply Wood Biomass

Respondents were questioned about the importance of different factors affecting their decision to supply (or not) wood biomass for a prospective Lee County wood-based bioenergy industry. Responses were based on a five point Likert scale (where 1=not important, and 5=very important).

Tables 3 and 4 demonstrates that the majority of respondents who are willing to supply wood biomass considered important the following factors in their decision making process: the 'right' price paid for wood biomass, presence of a stable market, investment cost for entering into the wood biomass market, contribution to local economy, contribution to energy self-reliance or climate change mitigation, and potential forest health benefit. Note that factors directly affecting forest landowners were considered more important in their decision to supply wood biomass when compared to factors indirectly affecting them. For example, potential economic benefit coming from wood biomass supply (the 'right price') was considered an extremely important factor affecting the decision of about half of the survey respondents willing to supply wood biomass for energy purposes (tables 3 and 4). However, addressing larger problems (e.g., energy security and climate change issues) was considered an extremely important factor by less than 30% of the respondents (tables 3 and 4).

For those landowners who said they were not interested in supplying wood biomass for a prospective wood-based bioenergy industry, the following factors were considered important: limited forestland size, the belief that economic benefit is not going to be worth the effort, disinterest in harvesting and disturbing the forestland at any price, and concern about ecological impacts at harvesting (tables 5 and 6). Limited size of forestland owned was considered the least important factor affecting respondents' decision; about one-third of the respondents who are not willing to supply wood biomass energy feedstock do not consider this factor important at all in their decision making (tables 5 and 6). Concern about the environmental impact at harvesting activities was higher for converting wood residues for energy than for converting timber (tables 5 and 6). Note in tables 5 and 6 that mean scores for those factors affecting respondents' decisions to not supply wood biomass hover around the mid-point on the five-point Likert scale (i.e., "moderately important"). Upon closer examination, however, we see that we have a bimodal response pattern. Higher proportions of respondents said that factors which might explain their unwillingness to sell timber or harvest residues either were “not important” or were “very important” (scored as 1 and 5, respectively) than “moderately important” (scored as a 3). The effect of this, however, is that mean scores alone are misleading.

To understand these bimodal distributions of unwillingness to supply timber and wood residues, respondents’ characteristics were investigated. Those landowners who said limited forestland was not important in their decision tended to receive a higher household income, less income from forestland, also owned more acres of forestland than those who said this factor was very important. Conversely, owners willing to supply biomass who identified limited land as a constraint did in fact have smaller holdings, less income from forestland, and lower household income. In addition, women considered limited land holdings more important than men.

Landowners who strongly believed economic benefit from wood biomass supply was not going to be worth the effort could not be differentiated from those who strongly agreed this activity would be economically beneficial, though the data suggest women believe less in economic benefits. Those landowners who are not interested in harvesting forestland for any price tended to own fewer acres of forestland and manage their forestland less intensively than those who do not consider this factor important. In addition, those landowners less willing to harvest their land independent of the price paid for wood tended to be younger, and half of them were female. Women also tended to care more than men about ecological impacts of harvesting activities when making decisions about selling. Similarly more educated landowners demonstrated more ecological reservations than these with lower educational achievements. In addition, most of those landowners who considered ecological impacts a very important reason for not supplying wood biomass do not actively manage their forestland.

4.2.2. Price Expected for Wood Biomass Materials

The ‘right’ price paid by wood biomass was considered an important factor influencing NIPF landowners’ decision to supply wood biomass for energy (tables 3 and 4). Although respondents did not know the exact price (in dollars) they would ask for wood biomass, the majority were able to relate expected prices based on other markets. For example, in the case of timber, 27% of respondents willing to supply this material for energy purposes would accept a price similar to that paid by pulpwood mills (table 7A). On the other hand, 35% of respondents willing to supply timber for energy production expected to receive a higher price for it, or a price similar to that paid by saw mills (table 7A), which is unrealistic The remaining respondents were unsure, or said they would accept a ‘fair’ price for their timber based on the quality of what they have on hand by the time of the timber sale.

Only 18% of respondents willing to supply wood residues for energy production said they would accept a low price paid for this material (or at least enough to cover harvesting costs) (table 7B). The majority of the respondents (77% of them) would be willing to supply wood residues for energy purposes if they could make some profit from this activity (or if they could receive more than the cost of harvesting activities) (table 7B), while the remaining respondents were not sure about what price to expect from wood residues.

NIPF landowners are a diverse population with different objectives for their forestland and different perceptions about local production of wood-based bioenergy.

Based on these factors, the willingness of respondents to supply wood biomass for a prospective wood-based bioenergy industry in Lee County was analyzed with carefull attention paid to respondents' demographic characteristics, their different motivations and attitudes toward their forestland, and their perspectives on local bioenergy production.

4.2.3. Respondents' Demographic Description

4.2.3.1. Age

According to Amacher, Conway and Sullivan (2003), different studies have demonstrated that many NIPF landowners in the US are approaching retirement age. Respondents to a NIPF landowner survey conducted by Bliss (1992) tended to be relatively old, with 40% 65 years of age or older. In contrast, only 2% of them were less than 35 years old. The present Lee County survey shows that a high percentage (86%) of the respondents are older than 50 years old (the majority of which are older than 60 or 70 years old), while only 1% reported being younger than 30 years old (table 8).

Older forest landowners represent the majority of the potential wood biomass suppliers for a prospective wood-based bioenergy industry in Lee County (table 8). As suggested by Koontz (2001), age is a factor expected to influence landowners' decision making; however, no statistically significant relationship was found between willingness to supply wood biomass and age (table 9). Even though many of our survey respondents are close to (or over) retirement age, this may not affect supply of wood biomass in the near future (next 10 years). No statistically significant relationship was found between age and willingness to sell timber or other forest products in the next 10 years (table 10).

4.2.3.2. Gender

Crim (2003) argued that women tend to participate less in forestland operation management than men. According to Crim (2003), female landowners tend to be older than male landowners, and usually acquire their land through inheritance. Women also tend to value forestland for reasons other than timber production (Crim 2003). In the present study, 90% of women respondents were older than 50 years old. Statistically significant relationships were found between gender and willingness to supply wood biomass both for timber and for residues (table 9). Women, accounting for only 22% of respondents, and holding 31% of the respondents' forest acres (table 8), appear to be less willing to supply either timber and wood residues for energy purposes than men.

4.2.3.3. Ethnicity

Bliss and Martin (1989) suggest that ethnicity is a strong predictor of attitudes and behaviors in forestry production. A significant portion of the survey respondents, and the ones holding the majority of the forestland, classified themselves as 'white' (table 8). Minorities, including African-Americans and one Asian-American, represented less than 5% of the respondent population (table 8).

African American landowners are experiencing the fastest land loss rates in the U.S., and a factor contributing to this land loss is the decreased economic returns coming from African Americans' typically small tracts of land (Crim 2003). African Americans represent 23% of Lee County's population (US Census Bureau 2007b); however, survey responses indicate this population owns only 1% of forestland (table 8). Probably because the number of respondents was as low, no statistically significant relationship was found between ethnicity and willingness to supply wood biomass for energy purposes (table 9), meaning that minority ethnic groups have as much interest in supplying this feedstock as other landowners.

4.2.3.4. Education

According to Bliss (1992), 10% of NIPF landowners in Alabama have not completed high school, while 40% of them have completed at least a college degree equivalent. In contrast, Lee County NIPF landowners are highly educated: less than 1% of the respondents have not completed high school, while 86% have some college education. One-third has completed a post-graduate degree. The presence of Auburn University in Lee County, and Tuskegee University in adjacent Macon County, may account for the relatively high educational attainment among our respondents. Koontz (2001) argues that education can play an important role in individuals’ norms and behaviors. It was hypothesized that higher levels of education would favor an increased interest in supplying of wood biomass for energy purposes; however, no statistically significant relationship was found between willingness to supply wood biomass and education (table 9). Nevertheless, well educated forest landowners hold the majority of the Lee County forestland potentially able to produce wood biomass (table 8).

4.2.3.5. Annual Household Income

The majority of the survey respondents can be considered wealthy; only about 10% of the respondents have an annual household income equal to or smaller than $40,000, while many respondents (about 1/3) receive an annual household income higher than $100,000 (table 8). No statistically significant relationship was found between household income and willingness to supply wood biomass (table 9), meaning that both poorer and richer forest landowners want to supply wood biomass in similar patterns.

However, landowners who receive higher income (more than $100,000 a year) are the ones who own the majority of the Lee County forestland (table 8), and represent those who could contribute the majority of the wood biomass supply in Lee County.

4.2.3.6. Economic Dependence on Forestland

Forest landowners who do not receive any income from forest-related activities represent the majority (54%) of the respondents' population, and about 21% of the respondents' forest acres (table 8). Another large group of forestland owners (42% of all respondents) receive 25% or less of their income from forest-related activities, and these landowners own about 62% of the total respondents' forestland acres (table 8). The remaining respondents (about 4% of them) receive more than 25% of their income from their forestland (table 8), owning about 1% of the total respondents' forestland acres. In total, the amount of forestland acres individually owned by these remaining landowners is low; however, the amount of forestland acres individually held by them is high (table 8).

A positive statistically significant correlation was found between economic dependence on forest-related activities and willingness to supply wood biomass (table 9), meaning that those respondents who depend more on forest-related activities as a source of income are the most willing to supply wood biomass. Note that the majority of the respondents who receive at least part of their household income from activities related to their forestland (although not usual) are already considered wealthy, with more than one-third of them receiving an annual household income of more than $100,000. Only about 10% those who receive a portion of their income from forest activities have an annual household income equal to or smaller than $40,000.

4.2.4. Respondents' Forestland Characteristics

4.2.4.1. Forestland Acres

Brodbeck (2005) suggests landowners with limited forestland resources are usually limited in their forest management practices. Landowners who own less forestland (especially fewer than 50 acres) might think that they do not own enough land to supply wood biomass. At the same time, forest landowners who own fewer forestland acres may own their forestland for reasons other than economic ones, and they might not be interested in managing or harvesting their forestland.

A statistically significant positive correlation was found between willingness to supply wood biomass and amount of forestland acres owned (table 10). Landowners who own more acres of forestland are more willing to supply both timber and wood residues for a prospective wood biomass industry in Lee County. These landowners also hold the majority of the Lee County forestland; 6% of survey respondents each own more than 500 acres of forestland in Lee County, but these landowners own more than half of the respondents' total acres (table 11). In contrast, landowners holding smaller forest acreage (less than 50 acres) own only 6% of the total respondents' forestland, even though they represent more than one-third of the respondents' total population (table 11).

4.2.4.2. Forest Species and Establishment

Tracts with only pine trees characterize 53% of the respondents' total acres (37% are planted pine and 16% are pine established through natural regeneration); indefinable tracts (described as a mix of pine and hardwood species) represent 29% of the respondents' acres; and straight hardwood tracts account for 18% of the respondents' acres (16% naturally established hardwood and 2% planted hardwood). Landowners who own pine forests could not be differentiated from those who own hardwood forests in their willingness to supply wood biomass (table 10 shows that that is no statistically significant relationship between tree species planted and willingness to supply wood biomass). However, those landowners who own planted forestland were more willing to supply timber in comparison to the ones who own naturally established forests (statistically significant positive correlation, table 10), while those landowners who own naturally established forests were more willing to supply wood residues in comparison to the ones who own planted forests (statistically significant negative correlation, table 10).

4.2.4.3. Engagement in Forestry Markets

The majority (72%) of landowners willing to sell timber or other forest products for bioenergy purpose have also sold these products in the past. Respondents who sold timber or forest products in the last 10 years, or plan to sell in the next 10 years, are more willing to supply wood biomass for energy purposes than those did not (or do not plan to) sell timber or other forest products (statistically significant correlation described on table 10). A high percentage of these landowners said they actively manage their forestland, many of whom are assisted by a professional during timber sale. These landowners also usually held large amounts of forestland.

4.2.4.4. Forestland Management Practices and Landowners' Attitudes Toward their Forestland

According to the survey, only 43% of the respondents (holding 79% of the total respondents' forest acres) actively manage their forestland. However, 75% of the survey respondents (representing 92% of the total respondents' forestland) are willing to manage their forestland for supplying wood biomass feedstock for a prospective Lee County bioenergy industry (table 12). This means that many NIPF landowners who do not currently manage their forestland are willing to do so for supplying wood biomass energy feedstock. Also, many of the forest landowners who already manage their forestland may be willing to integrate wood biomass production as part of their forest management practices. The fact that these landowners may be willing to replace their current forest management practices in order to produce wood biomass energy feedstock suggests that this new industry would encourage increased timber production if it came into being.

A statistically significant correlation was found between willingness to supply wood biomass and management of forestland (table 10). Respondents who manage their forestland tend to be more willing to supply both wood residues and timber than those who do not. Among forest management practices (site preparation, planting, seeding, thinning, pruning, selective harvesting, clear cutting, timber inventory, application of insecticide, application of herbicide, and burning control) only two, seeding and pruning, did not display a relationship with willingness to supply wood biomass (table 10). There was no difference among respondents who said they pruned their trees in their willingness to supply wood biomass (timber and wood residues) compared to those respondents who said they did not prune their trees. Tree pruning generally is done to improve the quality of trees grown for saw timber. Respondents who reported that they pruned their trees may not have known that pruning remains could be utilized for energy production.

Among landowners who said they manage their lands, 68% use professional services for advice about how to conduct management practices, while 15% said they use professional services to managing their land for them. In total, 42% of the land owned by respondents is managed by professionals. A statistically significant correlation was found between the use of forest management consultants and willingness to produce wood biomass – people who receive professional advice are more willing to supply wood biomass (timber and wood residues) than those who do not (table 10). A similar relationship was found between professional forest management and willingness to produce wood biomass – people who have their land managed by professionals are more willing to supply wood biomass (timber and wood residues) than those who do not (table 10).

4.2.4.5. Ownership Patterns (Leasing Forestland to and from Others)

Respondents own 79,809 acres of forestland in Lee County, 15% of which is leased to others. Only a few landowners (less than 3% of the respondents) said they lease forestland from others (a total of 2,373 acres, less than 3% of the respondent population's total forest acres). It was hypothesized that landowners who lease forestland (from and to others) would differentiate in their willingness to supply wood biomass in comparison to those who do not. However, no statistically significant relationship was found between leasing of forestland (to and from others) and willingness to supply wood biomass for energy purposes (table 10).

4.2.4.6. Engagement in National Conservation Programs

Almost all (18 out of 19) of the respondents with land enrolled in conservation programs said they would be willing to produce wood biomass on their land if the 'right' price were paid for it. However, only 5% of the respondents' population said they participate in at least one of conservation program, and the total amount of land currently in CRP (Conservation Reserve Program), EQIP (Environmental Quality Program) and

WHIP (Wildlife Habitat Incentive Program) represents only 3% of the respondents' total forestland.

It was hypothesized that landowners who take advantage of incentive programs, like CRP, EQIP and WHIP, would be willing to produce wood biomass on those lands if the price paid for the material was considered fair (equal to or better than what landowners receive from conservational subsidies). A positive, statistically significant correlation was found between willingness to supply timber and enrollment of forestland in current governmental incentive program (table 10). Landowners who currently have forestland in governmental programs are more willing to supply timber than those who do not; however, the same is not true regarding willingness to supply wood residues (table 10).

4.2.4.7. Forest Certification

Only 11% of the landowners (53 respondents) said they are certified by forest certification systems including Treasure Forest (30 respondents), American Tree Farm (20 respondents) and FSC (3 respondents); these landowners own 22% of the respondents' forest acres. Lee County certified forest landowners are more willing to supply timber for energy than non certified landowners (correlation table 10); however, certified forest landowners do not differentiate from non certified ones in their willingness to supply wood residues for energy purposes (see correlation in table 10).

It is important to note that all of the certified forest landowners said they actively manage their forestland; in addition, these landowners tend to own large amounts of forestland, and also tend to be already engaged in forest markets.

4.2.5. Forest Landowners' Motivations for Making Decisions about their Land

Respondents were asked, based on a Likert scale (1=not important, 2=of little importance, 3=moderately important, 4= important, and 5= very important), about the importance of different factors affecting decisions about their forestland. These factors include income from timber sales, income from hunting leases, income from other activities, investment for retirement, investment for a child's education, environmental stewardship, and land buffering for peace and quiet. Relationships between these variables and willingness to supply wood biomass are displayed in table 10, and frequency distributions are displayed in table 13.

The majority of the respondents do not consider important the following in their decision making: investment for child's future, cash income from hunting leases, and cash income from other activities (not including hunting lease and timber sale) (table 13). Nevertheless, the first two factors (investment for child's future and source of income from hunting lease) display a positive and weak statistically significant correlation to willingness to supply wood biomass (table 10).

When respondents were asked why they owned forestland, responses to "investment for retirement" exhibited a bimodal pattern (table 13). Respondents who considered this factor very important sold more timber in the past than those who considered this factor not important. These landowners also tended to receive more income from forestland, and to more actively manage their forestland. A positive, statistically significant correlation was found for this case (table 10).

A similar bimodal pattern was observed for the importance of cash income from timber sale (table 13) with a strong positive, statistically significant, correlation with willingness to supply wood biomass (table 10). Those landowners who considered income from timber a very important reason for owning their forestland own more forestland acres, more actively manage their forestland, and also sold more timber in the past than those who did not consider this factor important.

More than 85% of the respondents consider environmental stewardship an important reason for owning their forestland (table 13); however, no statistically significant correlation was found between environment stewardship and willingness to supply wood biomass. Finally, land buffering for peace and quiet at home was also considered either an "important" or "very important" factor by the majority of the respondents in their decisions to own forestland. Those who considered land buffering an important reason for owning forestland own fewer acres of forestland and receive less income from forestland than those who considered this factor not important. Not surprisingly, there was a statistically significant negative correlation between respondents' willingness to supply wood biomass and importance of land buffering personal residence (table 10).

A small number of respondents cited other factors of importance when making decisions about their land, including recreation (8 responses), future development of land (5 responses), and family estate (4 responses). All of the respondents who mentioned family estate and future development of land as important said they would be willing to supply both timber and wood residues for a prospective wood-based bioenergy industry; the ones who mentioned recreation as important were willing to supply only wood residues.

4.2.6. Knowledge and Perspectives about Wood Biomass and Bioenergy

More than half of the respondents were aware that wood could be used in production of biofuels such as ethanol; however, this knowledge seems to not influence landowners' decisions in supplying wood biomass for energy purposes (no statistically significant relationship was found according to table 10). Nevertheless, landowners who have attended workshops on the use of biomass for production of alternative forms of energy (only 10% of the respondents) are more willing to supply wood biomass energy feedstock than those who have not attended these workshops (positive statistically significant correlation, table 10).

Landowners were also asked about their agreement with the following statement: "The production of ethanol from wood will create important new economic opportunities for landowners in places like Lee County." The respondents who most agreed with the cited statement were more willing to supply both wood residues and timber for production of energy (positive statistically significant correlation, table 10).

4.3. PRINCIPAL COMPONENT ANALYSES

Principal Component Analysis (PCA) is a statistical technique utilized in empirical data summarization (Pallant 2005). It transforms a large set of variables, or components, into fewer sets of inter-correlated variables, called principal components. The more correlation is found among selected variables, the fewer principal components are needed to explain the variation in the total set of original data. In SPSS version 16, Principal Component Analysis is described as Data Reduction: Factor Analysis. Pallant (2005) argues that Principal Component Analysis is a form of Factorial Analysis (FA), and commonly we can find publications in which PCA components are described as factors (Pallant 2005).

Up to this point of our analysis, different variables have been related to forest landowners' willingness to supply wood biomass for energy production. However, we still do not have a clear picture of those variables that most influence respondents' decisions. Focusing on those respondents who said that they are willing to supply wood biomass for bioenergy production (questions 18 and 22 of the survey questionnaire described in appendix B), PCA analysis was conducted for selected variables.

In the first set of Principal Component Analysis, twenty six variables (or components) were selected, most of them highly correlated in cross-tabulations with the variables willingness to supply timber and willingness to supply wood residues. Eight principal components were retained in each case, each component presenting eigenvalue equal or higher than 1 (tables 14 and 16). Pallant (2005) argues that eigenvalues equal or higher than 1 should be retained in PCA. Tables 15 and 17 describe each of the twenty six initial components, while tables 14 and 16 give names to each of the eight extracted principal components. Percentages of variance in responses to willingness to supply wood biomass (timber and wood residues cases, respectively) are described in tables 14 and 16 (note that Varimax rotation was conducted in each analysis to facilitate interpretation of the results). In total, 64% and 63% of the variance in response to willingness to supply timber and wood residues, respectively, are explained by the eight retained factors (tables 14 and 16). In both analyses, the Kaiser-Meyer Olkin (KMO) measure of sampling adequacy exceeded recommended value of 0.6, and Bartlett's test of sphericity reached statistical significance ($p <$ than 0.5) (tables 14, 15, 16 and 17). Scree tests also confirm the retention of eight factors for each analysis (figures 1 and 2).

The second set of Principal Component Analysis achieved a higher percentage of variance explanation; however, the number of principal components extracted remained high, at the same time that initial components decreased in number. Six components, extracted from twelve initial variables, could explain 75% of the variance in response to willingness to supply timber (table 18). Also six components, extracted from thirteen initial variables, could explain 72% of the variance in response to willingness to supply wood residues (table 20). In both analyses, KMO was adequate and Bartlett's test of sphericity presented statistical significance (tables 18 and 20). Each principal component also presented an eigenvalue equal or higher than 1.0, and scree tests confirm the retention of six components in each analysis (figures 3 and 4).

According to the first set of analyzed components, forest management practices retain the majority of the variance in responses to willingness to supply timber and wood residues (first principal component described in table 14 and 16), which means that respondents who manage their forestland might be the ones most willing to supply wood biomass for a prospective Lee County wood-based bioenergy industry. The second principal component is represented by those landowners who are assisted in forest management practices and timber sales, also the ones who consider timber activities an important reason for owning their forestland (tables 15 and 17). Note that those landowners who characterize the first and second components also own large acreages of forestland (tables 15 and 17). The third and forth components (table 14 and 15) represent social status and economic dependence on forestland (inverse order in analysis based on wood residues, as described in table 15 and 16). Social status might also represent those landowners who do not live on their forestland, since they do not consider land buffering personal residence an important reason for owning it (negative correlation presented in tables 15 and 17). The fifth and sixth components (table 15) represent future orientation and income from non-timber activities (inverse order in analysis based on wood residues, as described in table 17). Finally, knowledge and interest regarding bioenergy represents the seventh most important component, being followed by gender (tables 15 and 17). Women explain 4% of the variance in responses to willingness to supply timber (table 14), while men explain 4% of the variance in responses to willingness to supply wood residues (table 16). However, keep in mind that the percentage of variance explained by gender is low, women represents only 22% of the respondent population (table 8), and results for this variable are contradictory given the fact that women are less willing than men to supply timber and wood residues (table 9).

The second set of analyzed components reinforces the importance of forest management practices in responses to willingness to supply wood biomass. In common with first set of analyses, this factor explains the majority of the variance in responses (first principal component described in tables 18 and 20). As with to the first set of analyzed components, those landowners who receive their income (or part of it) from their forestland are the second most important group in the second set (second component). Social status comes in third, including well educated and wealthier landowners. In fourth place are those landowners who receive income from activities other than timber sales, such as hunting lease. Future orientation comes in fifth, including those landowners who care about the potential ecological impacts of forest management practices, also the ones who seek future investments. Finally, those landowners who have attended workshops on bioenergy also contribute to significant part of the variance in responses to willingness to supply wood biomass for energy production.

Both sets of Principal Component Analysis demonstrate that ‘forest management practices’ explains the majority of the variance in responses to willingness to supply wood biomass. Almost the same factors could explain the variance in responses to willingness to supply timber and wood residues, and percentages of variance explanation for both cases also were similar. This makes sense given the fact that those percentages of respondents willing to supply timber and wood residues are similar (table 1), also considering that relationships between willingness to supply wood biomass (timber and wood residues) and selected variables are alike (tables 9 and 10). The second set of analyzed components display higher percentages of explanation of the variance in responses to supply wood biomass. However, few variables were utilized in those models, and some variables of importance were excluded. For example, it makes intuitive sense that the size of forestland holdings would be an important factor in determining willingness to sell timber or harvest residues. However, inclusion of this factor into the PCA decreased model validity (decreasing KMO values and also the percentage of total explanation of variance regarding willingness to supply wood biomass). Further research and analysis of data is required to understand these statistical findings. From Table 11, we see that seven percent of our respondents own over half of all forestland accounted for in the survey, that all of them are willing to supply timber and 96 percent of them are willing to supply harvest residues for production of biofuels. As size of holdings decreases, the percentage of respondents willing to supply biomass also decreases. One approach would be to disaggregate respondents into two or more categories defined by size of forestland ownership. A PCA model focusing on owners of less than 100 acres of forestland may differ from a model of respondents owning larger acreages.

6. CONCLUSIONS

Wood biomass is a potentially important energy feedstock in highly forested regions such as the U.S. South. Similar to that of the entire state, Lee County, Alabama, has 70% of its land covered by forestland, 83% of which is owned by non-industrial private forest (NIPF) landowners. Non-incorporated forest landowners, particularly individuals and families, have diverse reasons for owning their forestland, and these reasons are not always related to timber production. This study intended to evaluate the willingness of Lee County NIPF landowners, focusing on only individuals and families, to supply wood biomass for a prospective wood-based bioenergy industry.

Major objectives were accomplished. Survey results indicate that the majority of respondents are willing to supply wood biomass for a prospective wood-based bioenergy industry. If the survey is representative of the whole population, NIPF landowners (individuals/families) could make available 60% of total Lee County timberland for production of wood-based energy feedstock; this would be enough to replace the county's current liquid transportation fuel consumption with locally-produced second generation wood-based ethanol. Otherwise, wood biomass could be utilized in production of other kinds of energy, such as electricity and heating.

It is important to note that estimations were based on intensive forestland management. Although forest landowners could economically benefit from new wood-energy markets, the consequences of intensive production of short-rotation wood energy crops or wood residues harvesting on the environment are still uncertain. Many survey respondents were concerned about the potential ecological impacts of wood biomass production and harvesting in soil quality or wildlife habitats. At the same time, potential environmental consequences of exotic or genetically modified tree species may be an issue in the future. In this way, environmental modernization theory can still not promise growth and environmental stewardship in development of wood-based bioenergy industry.

In accordance to what were described by Bliss and Martin (1989), Koontz (2001), and Emtage et al. (2007), Lee County NIPF landowners (family/individuals) are influenced by diverse factors, financial and non-financial, when making decisions about their forestland. Conservational motivations and the economic benefit to the local community as a whole were considered important factors by many respondents in thinking about supplying of wood biomass. However, personal economic benefit was considered even more important by many respondents. Almost all of the respondents willing to supply wood biomass were willing to do so if the 'right' price was paid for the material.

For those not supporting supply of wood biomass, conservation were important for some, and others believed that economic benefits of this activity would be too small. As described by Elghali et al. (2007), decisions to participate in any new market will depend on the risks and gains associated to it. Many survey respondents considered their forestland size too small to benefit economically from bioenergy markets. Landowners who own more acres of forestland, those who already manage their forestland, and those who receive more income form timber sales are the most willing to supply wood biomass for a prospective bioenergy industry. This is probably because these landowners are less subjected to economic risks of this new wood market, otherwise the risks would not affect them in the same way of those landowners with fewer resources. Remember that respondents who managed their forestland tended to own larger forest acreages and also had higher incomes. Even though many of these respondents considered income from timber (and/or other activities) an important reason for owning their forestland, in general these landowners were not economically dependent on it.

It is important that extension specialists specify a minimum forestland size in which landowners could produce wood energy feedstock in a profitable way. In addition, financial incentives could be given to those landowners of limited resources, while technical support could be given to those landowners of limited knowledge about wood biomass production. In this way, not only better forest management practices could be achieved, but also a larger cross section of forest landowners could benefit from wood energy markets.

Note that even though wood has been utilized as an energy source throughout human history, the production of efficient wood-based bioenergy (e.g., wood-based ethanol or biopower) is still in its first stage. No plants currently are operating in Alabama or anywhere else in the U.S. The impacts of this kind of industry on the environment and on the society as a whole are still uncertain, and many policies are still to come. From this work we can conclude that development of wood-based bioenergy industries might contribute to diverse economic, environmental, and social impacts, negative or positive. If based on sustainable concepts, the chances of positive impacts of this kind of development might increase. One of the limitations of wood-based bioenergy development was solved: we know that in Lee County enough land is available for production of wood-based energy feedstock. The next step should be the investigation of potential wood-based bioenergy facilities, as well as the potential consumers of wood-based bioenergy.

The present study describes the characteristics of those landowners most willing to supply wood biomass feedstock, and also the potential constraints facing forest landowners who support supply of wood biomass (especially the ones with limited resources). The next logical step is to expand this survey to other parts of Alabama and the South to see if findings in Lee County can be applied more broadly.

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APPENDICES

APPENDIX A. Tables and Figures

Table 1. Descriptive statistics for selected variables.

Variables	Measures	N	Mean	Median	Mode
Willingness to supply timber	0=not willing; 1=willing	320	.69	1	1
Willingness to supply wood residues	0=not willing; 1=willing	337	0.79	1	1
Willingness to supply both (timber and wood residues)	0=not willing; 1=willing				
Age (years)	1=19-29; 2=30-39; 3=40-49; 4=50=59; 5=60=69; 6=70 more	354	4.71	5	6
Gender	0=Male; 1=Female	353	0.22	0	0
Ethnicity	1=White; 2=African American or other	349	1.04	1	1
Annual household income (thousand dollars)	1=less than 40; 2=40-60; 3=60-80; 4=80-100; 5= more than 100	305	3.55	4	5
Annual household income coming from forestland (%)	1=none; 2= less than 25; 3= 25-50; 4=50-75; 5=more than 75	345	1.50	1	1
Education	1=less than high school; 2= high school; 3=some college; 4=associates deg.; 5=bachelors deg., 6=post-graduate deg.	352	4.51	5	5
Forestland acres owned	1=0-50; 2=51-100; 3=101-200; 4=201-500; 5=more than 500	358	2.29	2	1
Lease forestland to others	0=No; 1=Yes	358	0.10	0	0
Lease forestland from others	0=No; 1=Yes	362	0.03	0	0
Have forestland on CRP, EQIP or WHIP	0=No; 1=Yes	354	0.06	0	0
Tree species owned	0=hardwood; 1= pine	86	0.79	1	1
Method of forest establishment	0=planted; 1=naturally established	115	0.54	1	1
Manage forestland	0=No; 1=Yes	348	0.43	0	0
Forest management practices:					
Site preparation	0=No; 1=Yes	363	0.19	0	0
Planting	0=No; 1=Yes	363	0.24	0	0
Seeding	0=No; 1=Yes	363	0.04	0	0
Thinning	0=No; 1=Yes	363	0.30	0	0
Pruning	0=No; 1=Yes	363	0.07	0	0
Selective harvesting	0=No; 1=Yes	363	0.23	0	0
Clear cutting	0=No; 1=Yes	363	0.15	0	0
Timber inventory	0=No; 1=Yes	363	0.09	0	0
Application of insecticide	0=No; 1=Yes	363	0.03	0	0
Application of herbicide	0=No; 1=Yes	363	0.13	0	0
Burning control	0=No; 1=Yes	363	0.18	0	0
Certified forester	0=No; 1=Yes	323	0.13	0	0

Table 1. Cont.

Variables	Measures	N	Mean	Median	Mode
Plan to sell timber in the next 10 years	0=No; 1=Unsure; 2=Yes	354	1.07	2	0
Sold timber in the last 10 years	0=No; 1=Yes	358	0.51	1	1
Use professional services for managing the land	0=No; 1=Yes	348	0.18	0	0
Use professional services for helping on timber sales	0=No; 1=Yes	350	0.42	0	0
Aware that wood can produce ethanol	0=No; 1=Yes	356	0.71	1	1
Attended wood biomass X energy workshop	0=No; 1=Yes	356	0.11	0	0
Agreement with statement: Lee Count forest landowners can be economically benefited by wood-based bioenergy markets	1=strongly disagree; 2=disagree; 3= unsure; 4= agree; 5= strongly agree	355	3.50	3	3
When making decision about forestland, importance of:					
Income from timber sales	1=Not important; 2=of little importance; 3= moderately important; 4= important; 5= very important	333	2.80	3	1
Income from hunting lease	1=Not important; 2=of little importance; 3= moderately important; 4= important; 5= very important	317	1.59	1	1
Income from other activities	1=Not important; 2=of little importance; 3= moderately important; 4= important; 5= very important	315	1.65	1	1
Investment for retirement	1=Not important; 2=of little importance; 3= moderately important; 4= important; 5= very important	319	3.01	3	1
Investment for child's education	1=Not important; 2=of little importance; 3= moderately important; 4= important; 5= very important	306	1.89	1	1
Environmental stewardship	1=Not important; 2=of little importance; 3= moderately important; 4= important; 5= very important	314	3.45	4	5
Land buffering personal residence	1=Not important; 2=of little importance; 3= moderately important; 4= important; 5= very important	310	3.36	4	5

Table 2. Willingness of Lee County NIPF landowners (individuals/families) to supply wood biomass feedstock for a prospective local wood-based bioenergy industry and respective forestland acres owned (N=363).

Landowners willing to supply:	Count (%)	Acres of forestland owned by respondents (total respondents' forest acres = 79,109)
Timber	220 (60.6 %)	66,109 (83.6%)
Wood residues	266 (73.3 %)	69,823 (88.3%)
Both timber and wood residues	201 (55.4 %)	63,233 (79.9%)
Either timber or wood residues, or both	274 (75.5 %)	72,699 (91.9%)

See Appendix B, questions 2, 18 and 22.

Table 3. Factors contributing to willingness to produce and sell timber for a prospective Lee County wood-based bioenergy industry (N=363).

Factors	N	Mean	Percentages				
			Not important	Of little importance	Moderately important	Important	Very important
The 'right price'	247	4.32	3.20	1.20	14.6	22.7	58.3
A steady market	236	3.56	11.0	9.70	22.9	25.4	30.9
Low investment costs	336	3.79	8.90	5.50	18.6	31.8	35.2
Addressing larger problems (e.g. energy security, global climate change)	240	3.45	11.7	13.8	20.8	25.4	28.3
Benefit the local economy as a whole	241	3.72	6.60	6.20	27.0	28.6	31.5

See Appendix B, question 20. Mean is based on a five-point Likert scale. The answers for the scale were 1 for 'not important', 2 for 'of little importance', 3 for 'moderately important', 4 for 'important', and 5 for 'very important.' Therefore the closer the mean is to 1, the less important the consideration. The closer the mean is to 5, the more important the consideration.

Table 4. Factors contributing to willingness to harvest and sell wood wastes and residues for a prospective Lee County wood-based bioenergy industry (N=363).

Factors	N	Mean	Percentages: Not important	Of little importance	Moderately important	Important	Very important
The ‘right price’	271	4.13	3.70	2.20	18.1	29.5	46.5
A steady market	261	3.44	13.0	9.60	24.9	25.7	26.8
Low investment costs	261	3.97	5.70	3.10	19.2	33.0	39.1
Addressing larger problems (e.g. energy security, global climate change)	260	3.45	10.8	10.8	25.8	27.7	25.0
Benefit the local economy as a whole	255	3.64	6.7	6.7	29.0	31.4	26.3
Improved forest health	254	4.16	2.8	3.5	16.1	29.9	47.6

See Appendix B, question 24. Mean is based on a five-point Likert scale. The answers for the scale were 1 for ‘not important’, 2 for ‘of little importance’, 3 for ‘moderately important’, 4 for ‘important’, and 5 for ‘very important.’ Therefore the closer the mean is to 1, the less important the consideration. The closer the mean is to 5, the more important the consideration.

Table 5. Factors contributing to respondents saying they would not produce and sell timber for a prospective Lee County wood-based bioenergy industry.

Factors	N	Mean	Percentages: Not important	Of little importance	Moderately important	Important	Very important
Limited forestland	107	2.59	36.4	13.1	19.6	16.8	14.0
Believe that economic benefit is not going to be worth the effort	116	3.13	22.4	11.2	19.8	24.1	22.4
Not interested in harvesting forest for any price	111	3.07	26.1	14.4	13.5	18.0	27.9
Concerned about the ecological impacts coming from harvesting activity	106	3.04	27.4	10.4	17.9	19.8	24.5

See Appendix B, question 21. Mean is based on a five-point Likert scale. The answers for the scale were 1 for ‘not important’, 2 for ‘of little importance’, 3 for ‘moderately important’, 4 for ‘important’, and 5 for ‘very important.’ Therefore the closer the mean is to 1, the less important the consideration. The closer the mean is to 5, the more important the consideration.

Table 6. Factors contributing to respondents saying they would <u>not</u> harvest and sell wood wastes and residues for a prospective Lee County wood-based bioenergy industry.

Factors	N	Mean	Percentages				
			Not important	Of little importance	Moderately important	Important	Very important
Limited forestland	73	2.82	34.2	12.3	11.0	21.9	20.5
Believe that economic benefit is not going to be worth the effort	77	3.06	27.3	14.3	11.7	18.2	28.6
Not interested in harvesting forest for any price	74	2.99	24.3	17.6	18.9	13.5	25.7
Concerned about the ecological impacts (on wildlife habitat) coming from harvesting activity	75	3.69	27.8	4.2	18.1	16.7	33.3
Concerned about the ecological impacts (on soil) coming from harvesting activity	72	3.24	20.0	4.0	12.0	14.7	49.3

See Appendix B, question 25. Mean is based on a five-point Likert scale. The answers for the scale were 1 for 'not important', 2 for 'of little importance', 3 for 'moderately important', 4 for 'important', and 5 for 'very important.' Therefore the closer the mean is to 1, the less important the consideration. The closer the mean is to 5, the more important the consideration.

Table 7. Respondents’ perceptions of the ‘right’ price expected for wood biomass.

A. Timber

Expected price	Percentages (N=208)
Equivalent to pulpwood	27
Not sure or a fair price	38
Equivalent to saw timber	35

See Appendix A, question 19.

B. Wood residues

Expected price	Percentages (N=204)
Enough to cover harvesting costs	18
Not sure or a fair price	5
More than harvesting costs	77

See Appendix B, question 23.

Table 8. Cross-tabulations of demographic characteristics, acres of forestland owned, and respondents' willingness to supply wood biomass.

Demographic description	Count (%)	Percentage willing to supply timber	Percentage willing to supply wood residues	Acres of forestland owned
Age				
19-29	3 (.8)	.6	.6	1840
30-39	10 (2.8)	2.2	2.1	931
40-49	37 (10.5)	7.6	9.6	7771
50-59	95 (26.8)	20	23.4	18603
60-69	101 (28.5)	20.6	21.9	22072
70 or more	108 (30.5)	17.5	21.3	27101
Gender				
Male	275 (77.9)	58.6	65.2	60250
Female	78 (22.1)	9.9	13.5	17578
Ethnicity				
White	336 (95.2)	66	75.4	77326
Afro-American	16 (4.4)	2.2	3.3	628
Other	1 (.4)	.6	.6	352
Annual household income in thousand dollars				
40 or less	36 (11.8)	7.4	8	4339
Over 40 - 60	50 (16.4)	8.9	12.2	4210
Over 60 - 80	50 (16.4)	10	13.9	6678
Over 80 - 100	49 (16.1)	11.9	12.2	9067
Over 100	120 (39.3)	31.25	33.7	43332
Percentage of annual household income coming from forestland				
None	188 (54.5)	27.4	37.4	16605
25 or less	145 (42)	38.1	38	48874
Over 25 - 50	9 (2.6)	2.3	2.5	6094
Over 50 - 75	2 (.6)	.3	.6	1018
Over 75	1 (.3)	.3	.3	104
Education				
Less than high school	3 (.9)	.3	.3	194
High school or GED	36 (10.2)	6.1	5.7	3191
Some college or university	69 (19.6)	12.1	16	10608
Associates degree	25 (7.1)	4.2	5.7	3213
Bachelor's degree	110 (31.3)	21.4	26.2	35127
Post-graduate degree	109 (31)	24.6	25	25466

See Appendix B, questions 28,29,30,31,32 and 33.

Table 9. Chi-square and correlation between willingness to supply wood biomass and selected landowner characteristics.

Independent variables	Timber		Wood Residues		Both	
	X²	R	X²	R	X²	R
Age	2.140	-.043	5.533	-.117*	3.833	-.109
Gender	13.549**	-.208**	10.945**	-.181**	11.988**	-.218**
Ethnicity	1.967	.025	3.210	.009	2.618	.039
Annual household income	7.025	.125	3.256	.081	4.578	.129
Annual household income coming from forestland	53.497**	.417**	25.454**	.279**	43.785**	.417**
Education	4.891	.096	10.883	.079	8.298	.101

* p> .05 **p>.01 (two-tailed tests)

Table 10. Chi-square and correlation between willingness to supply wood biomass and selected independent variables.

Independent variables	Timber		Wood Residues		Both	
	X²	R	X²	R	X²	R
Forestland acres *owned*	31.134**	.285**	20.067**	.200**	23.129**	.287**
Lease forestland to others	1.676	.068	.286	-.001	1.070	.061
Lease forestland from others	2.186	.083	.981	.054	2.300	.095
Have forestland on CRP, EQIP or WHIP	6.585**	.145**	3.032	.096	3.041	.109
Tree species	14.575**	.4.35**	3.082*	.199*	13.343**	.476**
Forest establishment	6.819**	-.261**	1.768	-.128	5.006**	-.257**
Manage forestland	17.054**	.235**	16.620**	.225**	18.526**	.272**
Site preparation	26.934**	.290**	13.474**	.200**	17.253**	.259**
Planting	39.067**	.349**	20.173**	.245**	27.867**	.329**
Seeding	1.234	.062	1.213	.060	.849	.057
Thinning	12.895**	.201**	8.523**	.159**	12.832**	.223**
Pruning	1.903	.077	.309	.030	1.313	.072
Selective harvesting	5.401*	.130*	4.631*	.117*	6.707**	.162**
Clear cutting	16.611**	.228**	8.978**	.163**	10.377**	.201**
Timber inventory	9.825**	.175**	4.669*	.118*	4.558*	.133*
Application of insecticide	4.692*	.121*	2.751	.090	2.899	.106
Application of herbicide	12.720**	.199**	7.391**	.148**	9.972**	.197**
Burning control	12.048**	.194**	12.389**	.192**	12.317**	.219**
Certified forester	14.173**	.221**	3.468*	.106	6.711**	.170**
Sold timber in the last 10 years	15.956**	.224**	4.205*	.112*	11.715**	.214**
Plan to sell timber in the next 10 years	85.986**	.522**	53.506**	.397**	82.806**	.563**
Use professional services for forestland management advises	37.678**	.347**	16.740**	.225**	28.033**	.334**
Use professional services for managing the land	23.386**	.276**	9.105**	.167**	15.174**	.247**
Use professional services for helping on timber sales	34.161**	.332**	17.119**	.228**	31.426**	.355**
Aware that wood can produce ethanol	.546	.041	.235	-.026	.108	.021
Attended wood-base bioenergy workshop	3.686*	.107*	1.249	.061	2.770	.104
Agreement with the statement: "Lee Count forest landowners can be economically benefited by wood-based bioenergy markets"	40.736**	.340**	18.701**	.232**	30.051**	.334**
When making decision about land, importance of:						
Income from timber sale	67.605**	.444**	31.939**	.295**	64.521**	.466**
Income from hunting lease	22.413**	.266**	7.810	.134*	14.417**	.243**
Income from other activity	5.720	.079	9.648*	.050	7.616	.063

Table 10 Cont.

Independent variables	Timber		Wood Residues		Both	
	X^2	R	X^2	R	X^2	R
Investment for retirement	19.082**	.214**	15.193**	.188**	21.676**	.267**
Investment for child's future	11.258*	.184**	9.376*	.177**	13.045**	.232**
Environmental stewardship	8.971	-.023	12.151*	.69	11.524*	.023
Land buffering personal residence for peace and quiet	20.344**	-.193**	15.791**	-.138*	18.474**	-.163**

* p> .05 **p>.01 (two-tailed tests)

Table 11. Forestland owned by respondents and correspondent percentages of respondents willing to supply wood biomass.

Acres of forestland owned by respondents	Percentage (N=358)	Percentage of respondents' total forestland	Percentage willing to supply timber	Percentage willing to supply wood residues
50 or less	37	6	57	69
51-100	24	9	58	82
101-200	20	13	74	73
201-500	13	20	90	96
500-more	7	52	100	96

See Appendix B, questions 2, 18, and 22.

Table 12. Respondents currently managing their forestland and those respondents willing to manage their forestland for production of wood biomass.

Respondents…	Percentage	Equivalent forest acres owned
…currently managing forestland	43	62,496 (79%)
…willing to manage forestland for wood biomass production	75	72,699 (92%)

See Appendix B questions 8, 18 and 22.

Table 13. Importance of the following factors when making decision about forestland.

Factors	N	Mean	Percentages				
			not important	of little importance	moderately important	important	very important
Source of cash income from timber sale	333	2.80	32.1	14.7	15.6	15.9	21.6
Source of cash income from hunting lease	317	1.59	74.4	8.8	6.3	4.1	6.3
Source of cash income from other activities	315	1.65	71.7	8.6	8.6	4.8	6.3
Investment for retirement	319	3.01	27.0	11.0	20.1	17.9	24.1
Investment for child's education	306	1.89	60.8	12.4	12.4	6.2	8.2
Environmental stewardship	314	3.45	14.0	8.0	25.2	25.2	27.7
Land buffering for quiet and peace	310	3.36	27.1	5.8	11.6	14.8	40.6
Others	24	5.00	0.0	0.0	0.0	0.0	100.0

See Appendix B, question 13.

Others= recreation (N=12), family land state (N=5), and capital appreciation/development (N=7).

Mean is based on a five-point Likert scale. The answers for the scale were 1 for ‘not important’, 2 for ‘of little importance’, 3 for ‘moderately important’, 4 for ‘important’, and 5 for ‘very important.’ Therefore the closer the mean is to 1, the less important the consideration. The closer the mean is to 5, the more important the consideration.

Table 14. Total variance explained by eight principal components extracted from twenty six initial components in analysis performed to understand willingness to supply timber.

Principal Components	Rotation Sums of Squared Loadings		
	Total (eigenvalue)	% of Variance	Cumulative %
1. Forest management practices	4.497	17.297	17.297
2. Forest management objectives	2.885	11.095	28.392
3. Social status	1.842	7.085	35.477
4. Engagement in forest markets	1.777	6.835	42.312
5. Future orientation	1.584	6.093	48.404
6. Non-timber income	1.555	5.980	54.384
7. Perspectives and knowledge on bioenergy	1.467	5.641	60.026
8. Gender	1.251	4.811	64.837

Extraction Method: Principal Component Analysis.
Only cases for which willingness to supply timber = yes are used in the analysis phase.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) = .810.
Bartlett's Test of Sphericity: Approx. Chi-Square = 703.945, df = 325.000, Sig. = .000.

Table 15. Rotated component matrix for twenty six initial components analyzed to understand willingness to supply timber.

	Principal Components (for labels see table 14)							
Initial components	1	2	3	4	5	6	7	8
Site preparation	.822							
Planting seedlings	.800							
Clear cutting	.795							
Burning	.747							
Use of herbicides	.715							
Thinning	.676			.353				
Selective harvesting	.590			.395				
Forestland acres owned	.463	.414						
Receive forest management advice	.330	.778						
Receive timber sale advice		.773						
Income from timber		.624						
Professional manages forestland		.608						
Plan to sell timber		.488			.405			.330
Education			.822					
Household income			.789					
Land buffering			-.528		.336			
Receive income from forestland				.754				
Sold timber in the past	.317			.692				
Investment for retirement					.723			
Environmental stewardship					.717			
Income from other activity						.782		
Income from hunting lease		.304				.706		
Attended workshop							.793	
Believe forest landowners can economically benefit							.568	.336
Knowledge about biofuel							.557	-.417
Gender								.775

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 8 iterations.
Only cases for which willingness to supply timber = yes were used in the analysis phase. KMO = .810, and Bartlett's Test Sig. = .000.

Table 16. Total variance explained by eight principal components extracted from twenty six initial components in analysis performed to understand willingness to supply wood residues.

Principal Components	Rotation Sums of Squared Loadings		
	Total (eigenvalue)	% of Variance	Cumulative %
1. Forest management practices	4.194	16.130	16.130
2. Forest management objectives	2.955	11.367	27.498
3. Engagement in forest markets	1.777	6.836	34.333
4. Social status	1.737	6.680	41.013
5. Non-timber income	1.572	6.047	47.060
6. Future orientation	1.540	5.923	52.983
7. Perspectives and knowledge on bioenergy	1.398	5.379	58.362
8. Gender	1.291	4.965	63.327

Extraction Method: Principal Component Analysis.
Only cases for which willingness to supply wood residues = yes are used in the analysis phase.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) = .835.
Bartlett's Test of Sphericity: Approx. Chi-Square = 973.684, df = 325.000, Sig. = .000.

Table 17. Total variance explained by eight principal components extracted from twenty six initial components in analysis performed to understand willingness to wood residues.

	Principal Components (for labels see table 16)							
Initial components	1	2	3	4	5	6	7	8
Site preparation	.775							
Planting seedlings	.760	.344						
Clear cutting	.757							
Burning	.752							
Use of herbicides	.719							
Thinning	.602		.364					
Selective harvesting	.518		.451					
Forest acres owned	.502	.379						
Receive timber sale advice		.773						
Receive forest management advice	.349	.764						
Professional manages forestland	.317	.628						
Income from timber		.614			.344			
Receive income from forestland			.673					
Sold timber in the past	.314		.668					
Education				.803				
Household income				.786				
Land buffering		-.404		-.495				
Income from other activities					.796			
Income from hunting lease		.300			.689			
Environmental stewardship						.761		
Investment for retirement						.686		
Attended workshop							.797	
Knowledge about biofuel							.523	.481
Believe forest landowners can economically benefit						.380	.464	
Gender								-.706
Plan to sell timber		.303						.559

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 8 iterations.
Only cases for which willingness to supply wood biomass = yes were used in the analysis phase.
KMO = .835, and Bartlett's Test Sig. = .000.

Table 18. Total variance explained by six principal components extracted from twelve initial components in analysis performed to understand willingness to supply timber.

Principal Components	Rotation Sums of Squared Loadings		
	Total (eigenvalue)	% of Variance	Cumulative %
1. Forest management	2.030	16.920	16.920
2. Engagement in forest markets	1.640	13.664	30.584
3. Social status	1.529	12.743	43.327
4. Non-timber income	1.407	11.728	55.054
5. Future orientation	1.331	11.090	66.145
6. Knowledge about bioenergy	1.085	9.039	75.183

Extraction Method: Principal Component Analysis.
Only cases for which willingness to supply timber = yes are used in the analysis phase.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) = .637.
Bartlett's Test of Sphericity: Approx. Chi-Square = 368.696, df = 66.000, Sig. = .000.

Table 19. Rotated component matrix for twelve initial components based on willingness to supply timber.

Initial components	Principal Components (for labels see table 18) 1	2	3	4	5	6
Site preparation	.831					
Use of herbicides	.828					
Thinning	.687	.429				
Receive income from forestland		.827				
Sold timber in the past		.805				
Household income			.877			
Education			.836			
Income from other activity				.821		
Income from hunting lease				.800		
Environmental stewardship					.799	
Investment for retirement					.778	
Attended workshop on bioenergy						.931

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations.
Only cases for which willingness to supply timber = yes were used in the analysis phase.
KMO = .637, and Bartlett's Test Sig. = .000.

Table 20. Total variance explained by six principal components extracted from thirteen initial components in analysis performed to understand willingness to supply wood residues.

	Rotation Sums of Squared Loadings		
Principal Components	Total (eigenvalue)	% of Variance	Cumulative %
1. Forest management	2.602	20.015	20.015
2. Engagement in forest markets	1.618	12.448	32.463
3. Social status	1.468	11.290	43.753
4. Non-timber income	1.367	10.516	54.270
5. Future orientation	1.288	9.905	64.174
6. Knowledge about bioenergy	1.045	8.041	72.215

Extraction Method: Principal Component Analysis.
Only cases for which willingness to supply wood residues = yes are used in the analysis phase.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) = .725.
Bartlett's Test of Sphericity: Approx. Chi-Square = 563.438, df = 78.000, Sig. = .000.

Table 21. Rotated component matrix for thirteen initial components based on willingness to supply wood residues.

Initial components	Principal Components (for labels see table 20) 1	2	3	4	5	6
Planting seedlings	.857					
Site preparation	.821					
Use of herbicides	.765					
Thinning	.623	.395				
Receive income from forestland		.804				
Sold timber in the past	.312	.783				
Household income			.848			
Education			.830			
Income from other activity				.815		
Income from hunting lease				.778		
Environmental stewardship					.829	
Investment for retirement					.744	
Attended workshop on bioenergy						.944

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations.
Only cases for which willingness to supply wood residues = yes were used in the analysis phase.
KMO = .725, and Bartlett's Test Sig. = .000.

Figure 1. Scree plot for the twenty six initial components analyzed to understand willingness to supply timber.

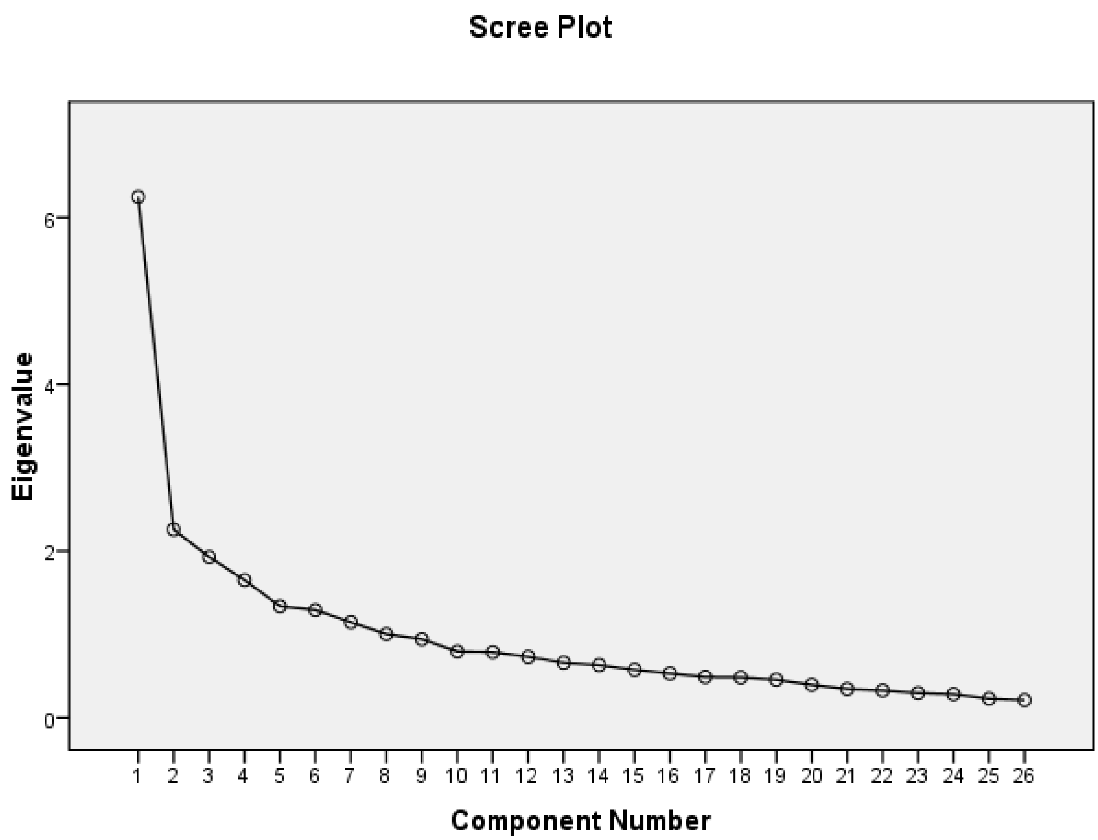


Figure 2. Scree plot for the twenty six initial components analyzed to understand willingness to supply wood residues.

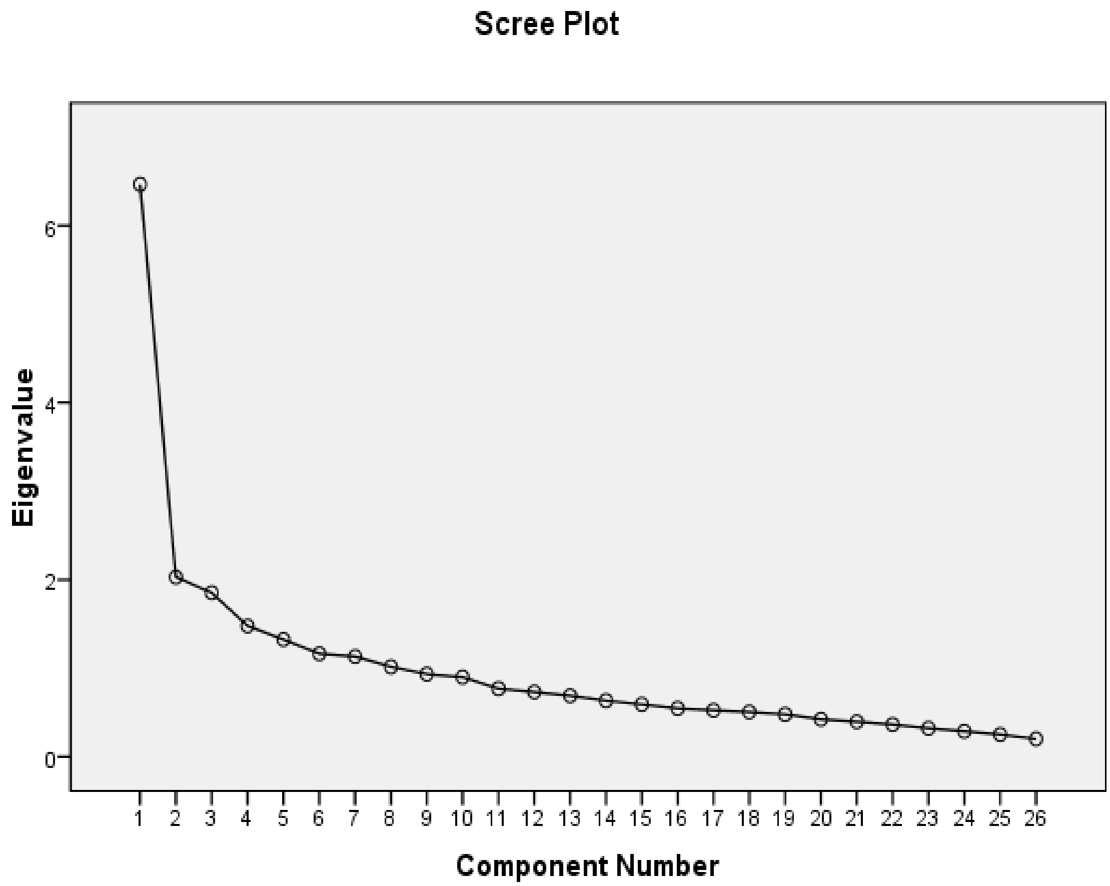


Figure 3. Scree plot for the twelve initial components analyzed to understand willingness to supply wood residues.

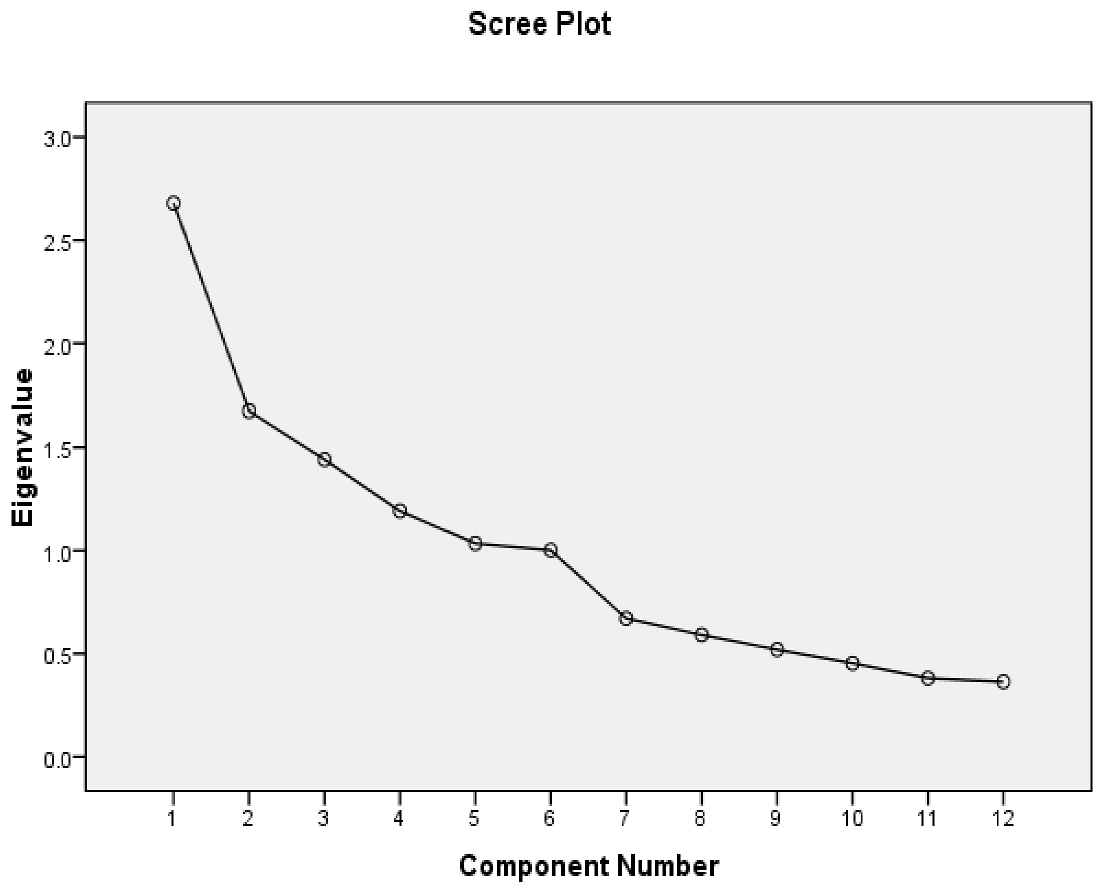
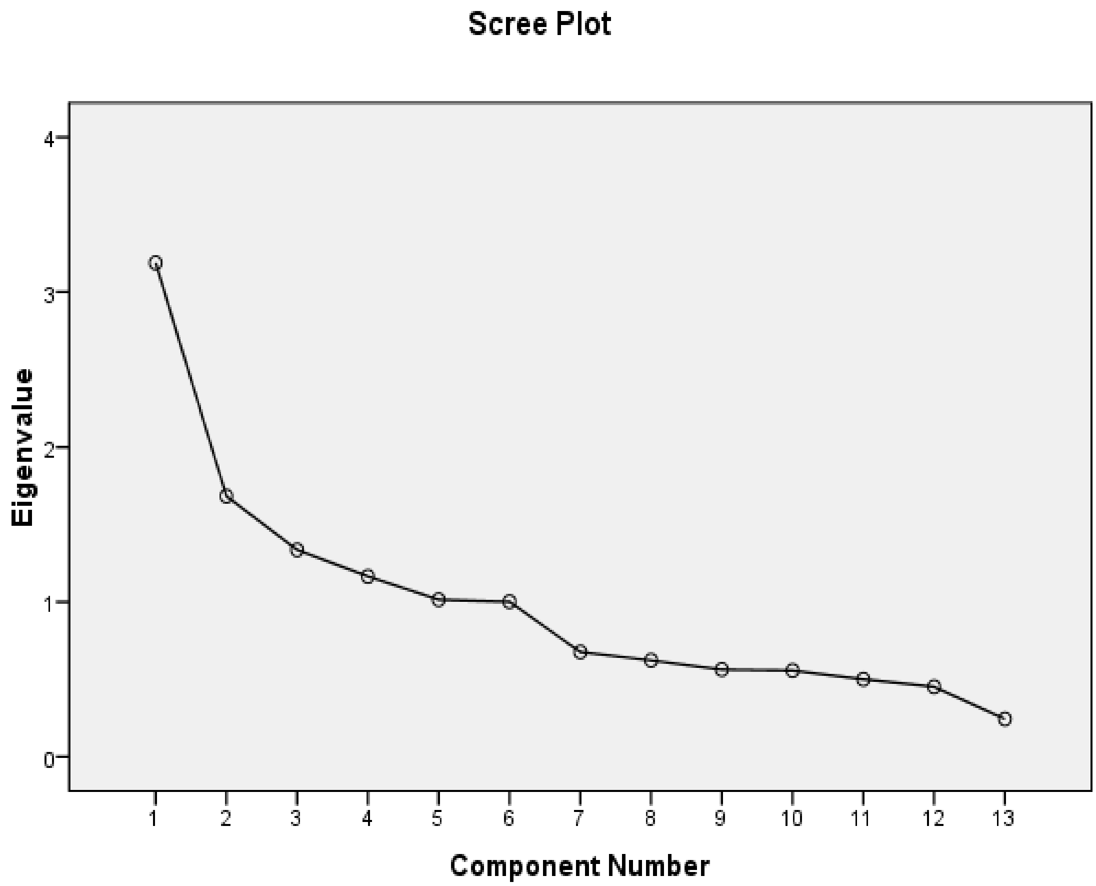
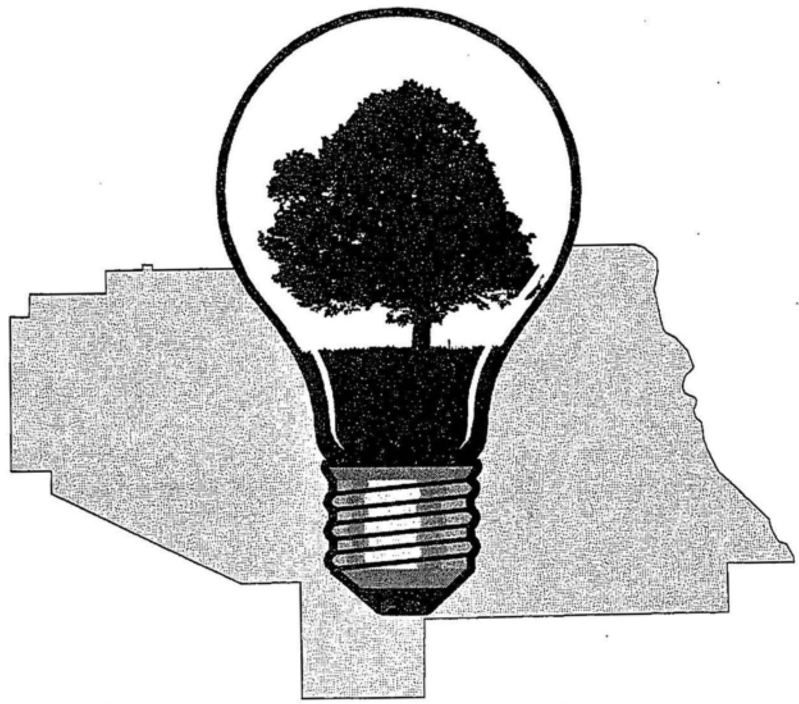


Figure 4. Scree plot for the thirteen initial components analyzed to understand willingness to supply wood residues.



APPENDIX B. Questionnaire

Opportunities and Constraints Facing the Development of Wood-Based Bioenergy Systems in Lee County, Alabama



A survey of how bioenergy can contribute to new economic opportunities for forest landowners in Lee County, Alabama

Cooperative Research Project
School of Forestry and Wildlife Sciences
Department of Agricultural Economics and Rural Sociology
Auburn University, Auburn – Alabama

Thank you in advance for helping us with this survey. Your answers will help us understand how wood-based bioenergy can contribute to new economic opportunities for forest landowners in Lee County, Alabama.

PART 1: FOREST LAND and YOURSELF

We would like to start by asking you a few questions about the forest land you own and/or lease in Lee County.

1. Do you currently own and/or lease any forest land in Lee County?

   ☐ Yes (please proceed with remaining questions)
   ☐ No (please return blank questionnaire in enclosed stamped envelope)

2. How many acres of forest land (in Lee County) do you own and/or lease from others?

   I own ___________ acres
   I lease from others ___________ acres

3. If you own any forest land in Lee County, do you lease any of it to others?

   ☐ Yes
   ☐ No

   If "yes", please specify the number of acres: _________acres

4. Is any of the forest land you own (in Lee County) in the Conservation Reserve Program (CRP), Environmental Quality Incentive program (EQIP) and/or Wildlife Habitat Incentive Program (WHIP)?

   ☐ Yes
   ☐ No

   If "yes", please specify the amount of many acres in: CRP _______ acres
   EQIP _______ acres
   WHIP_______ acres

5. In the past 10 years, have you sold timber or other forest products from the land you own and/or lease from others in Lee County?

Forest land owned

☐ Yes
☐ No

Forest land leased from others

☐ Yes
☐ No

6. In the next 10 years, do you plan to sell timber or other forest products from the land you own and/or lease from others in Lee County?

Forest land owned

☐ Yes
☐ No
☐ Unsure

Forest land leased from others

☐ Yes
☐ No
☐ Unsure

7. Please indicate which of the following vegetation types most accurately describes the forest land you own and/or lease from others in Lee County-AL, also indicating the number of acres:

Vegetation type	Acres of land owned	Acres of land leased from others
Planted pine		
Pine (established through natural seeding)		
Hardwood (established through natural seeding		
Planted hardwood		
Mixed pine and hardwood		
Other (please explain) ____________		

3

8. Do you actively manage the forest land you own and/or lease from others (e.g. plant trees, control against pests and wildfire, thin trees or harvest trees, etc.)?

☐ Yes (please proceed to question 9)
☐ No (please skip to question 10)

9. Please indicate the forest management practices that you have used on the land you own and/or lease from others in the past 10 years (mark all that apply):

Forest land you <u>own</u>

☐ Site preparation
☐ Planting seedlings
☐ Seeding
☐ Thinning
☐ Pruning
☐ Selective harvesting
☐ Clear cutting
☐ Timber inventory
☐ Use of insecticides
☐ Use of herbicides
☐ Burning
☐ Other (please explain) ____________
____
____
____

Forest land you lease <u>from</u> others

☐ Site preparation
☐ Planting seedlings
☐ Seeding
☐ Thinning
☐ Pruning
☐ Selective harvesting
☐ Clear cutting
☐ Timber inventory
☐ Use of insecticides
☐ Use of herbicides
☐ Burning
☐ Other (please explain)____________
____
____
____

10. Do you use the professional services of anyone else to <u>advise you in forest management practices</u>?

☐ Yes
☐ No

11. Do you use the professional services of anyone else to <u>manage forest land for you</u>?

☐ Yes
☐ No

12. Do you use the professional services of anyone else to assist you with the sale of timber or other forest products?

☐ Yes
☐ No

13. Please rank the importance of the following factors in making decisions about the forest land you own and/or lease from others (1 = Not Important; 2 = Of Little Importance; 3 = Moderately Important; 4 = Important; 5 = Very Important):

Forest land you own

	IMPORTANCE *Low* — *High*
Source of cash income from timber sales	1☐ 2☐ 3☐ 4☐ 5☐
Source of cash income from hunting lease	1☐ 2☐ 3☐ 4☐ 5☐
Source of cash income from other activities	1☐ 2☐ 3☐ 4☐ 5☐
Investment for retirement	1☐ 2☐ 3☐ 4☐ 5☐
Investment for child's education	1☐ 2☐ 3☐ 4☐ 5☐
Environmental stewardship	1☐ 2☐ 3☐ 4☐ 5☐
Land buffering personal residence for peace and quiet	1☐ 2☐ 3☐ 4☐ 5☐
Other (please explain)________________________	1☐ 2☐ 3☐ 4☐ 5☐

Forest land you lease from others

	IMPORTANCE *Low* — *High*
Source of cash income from timber sales	1☐ 2☐ 3☐ 4☐ 5☐
Source of cash income from hunting lease	1☐ 2☐ 3☐ 4☐ 5☐
Source of cash income from other activities	1☐ 2☐ 3☐ 4☐ 5☐
Investment for retirement	1☐ 2☐ 3☐ 4☐ 5☐
Investment for child's education	1☐ 2☐ 3☐ 4☐ 5☐
Environmental stewardship	1☐ 2☐ 3☐ 4☐ 5☐
Land buffering personal residence for peace and quiet	1☐ 2☐ 3☐ 4☐ 5☐
Other (please explain)________________________	1☐ 2☐ 3☐ 4☐ 5☐

14. Please indicate which of the following certification systems currently certifies the land you own and/or lease from others:

Forest land you <u>own</u>

☐ Treasure Forest
☐ American Tree Farm
☐ Forest Stewardship Council
☐ None
☐ Other (please explain) ____________
____

Forest land you lease <u>from</u> others

☐ Treasure Forest
☐ American Tree Farm
☐ Forest Stewardship Council
☐ None
☐ Other (please explain)____________
____

PART 2: BIOERNERGY and YOUR THOUGHTS

Next we would like to ask you a few questions about your thoughts on using wood biomass for production of alternative forms of energy. Wood biomass (any kind of wood including also wood residues and wastes) can be used as feedstock in production of energy (e.g. electricity, heating power, biofuels like ethanol, among others).

15. Were you previously aware that wood can be used to make biofuels such as ethanol?

☐ Yes
☐ No

16. Have you ever attended a workshop on the use of wood biomass for production of alternative forms of energy?
☐ Yes
☐ No

17. Please indicate how strongly you agree or disagree with the following statement: "The production of ethanol from wood will create important new economic opportunities for land owners in places like Lee County, Alabama".

☐ Strongly Disagree
☐ Disagree
☐ Unsure
☐ Agree
☐ Strongly Agree

TIMBER: We would like to ask you a few questions about the production and marketing of timber.

18. If there was a market for the product, would you be willing to produce and sell timber for conversion to ethanol or other alternative forms of energy?

    ☐ Yes (please proceed to question 19)
    ☐ No (please skip to question 21)

19. How would you calculate the 'right price' that would lead you to produce and sell timber for conversion to ethanol or other alternative forms of energy?

    ☐ I would expect the same price as I would get from the sale of pulpwood
    ☐ I would expect the same price as I would get from the sale of saw timber
    ☐ I would expect $ (_________) dollars per green/ton of wood
    ☐ Other (please explain) ____
    ____
    ____

20. Please rank the importance of the following factors in your decision to produce and sell timber for conversion to ethanol or other alternative forms of energy (1 = Not Important; 2 = Of Little Importance; 3 = Moderately Important; 4 = Important; 5 = Very Important):

	IMPORTANCE *Low* → *High*
The 'right price'	1☐ 2☐ 3☐ 4☐ 5☐
A steady market (e.g. a multiple year contract)	1☐ 2☐ 3☐ 4☐ 5☐
Low investment costs	1☐ 2☐ 3☐ 4☐ 5☐
A sense that I was contributing to addressing larger problems (e.g. energy security, global climate change)	1☐ 2☐ 3☐ 4☐ 5☐
A sense that local production of energy would benefit the local economy as a whole)	1☐ 2☐ 3☐ 4☐ 5☐
Other (please explain) ____________________________	1☐ 2☐ 3☐ 4☐ 5☐

7

21. If you answered **NO** in question 18, please rank the importance of the following factors in your decision about not producing and selling timber for conversion to ethanol or other alternative forms of energy (1 = Not Important; 2 = Of Little Importance; 3 = Moderately Important; 4 = Important; 5 = Very Important):

	IMPORTANCE *Low* *High*
The forest land I own is so limited that I might not find anybody to harvest it	1☐ 2☐ 3☐ 4☐ 5☐
I think the economic benefit to me is not going to be worth the effort	1☐ 2☐ 3☐ 4☐ 5☐
I am not interested in harvesting my forest for any price	1☐ 2☐ 3☐ 4☐ 5☐
I am concerned about the ecological impacts of planting and harvesting timber	1☐ 2☐ 3☐ 4☐ 5☐
Other (please explain) ______________________________	1☐ 2☐ 3☐ 4☐ 5☐

WOOD WASTES AND RESIDUES: We would like to ask you a few questions about harvesting and marketing wood wastes and residues (thinnings, limbs, branches, wood chips, damaged trees, etc.).

22. If there was a market for the product, would you be willing to harvest and sell wood wastes and residues for conversion to ethanol or other alternative forms of energy?

☐ Yes (please proceed to question 23)
☐ No (please skip to question 25)

23. How would you calculate the 'right price' that would lead you to harvest and sell wood wastes and residues from the forest land you own and/or lease from others for conversion to ethanol or other alternative forms of energy:

☐ I would expect enough to cover the cost of harvesting wood wastes and residues
☐ I would expect that the price paid for the wood wastes and residues would be higher than the cost expended on harvesting them
☐ I would expect $ (________) dollars per ton of wood wastes and residues materials
☐ Other (please explain) ______________________________

24. Please rank the importance of the following factors in your decision to harvest and sell wood wastes and residues for conversion to ethanol or other alternative forms of energy (1 = Not Important; 2 = Of Little Importance; 3 = Moderately Important; 4 = Important; 5 = Very Important):

	IMPORTANCE *Low High*
The 'right price'	1☐ 2☐ 3☐ 4☐ 5☐
A steady market (e.g. a multiple year contract)	1☐ 2☐ 3☐ 4☐ 5☐
Low investment cost for harvesting wastes and residues	1☐ 2☐ 3☐ 4☐ 5☐
A sense that I was contributing to addressing larger problems (e.g. energy security, global climate change, etc.)	1☐ 2☐ 3☐ 4☐ 5☐
A sense that local production of energy would benefit the local economy as a whole	1☐ 2☐ 3☐ 4☐ 5☐
Less risks for wildfire and tree diseases due to removal of damaged trees and wood biomass excess	1☐ 2☐ 3☐ 4☐ 5☐
Other (please explain)________________________ ______________________________	1☐ 2☐ 3☐ 4☐ 5☐

25. If you answered NO in question 22, please rank the importance of the following factors in your decision about not harvesting and selling wood wastes and residues for conversion to ethanol or other alternative forms of energy (1 = Not Important; 2 = Of Little Importance; 3 = Moderately Important; 4 = Important; 5 = Very Important):

	IMPORTANCE *Low High*
The forest land I own is so limited that I might not find anybody to harvest it	1☐ 2☐ 3☐ 4☐ 5☐
I think the economic benefit to me is not going to be worth the effort	1☐ 2☐ 3☐ 4☐ 5☐
I am not interested in harvesting my wood wastes and residues for any price	1☐ 2☐ 3☐ 4☐ 5☐
I am concerned about the ecological impacts on soil quality from harvesting wood wastes and residue	1☐ 2☐ 3☐ 4☐ 5☐
I am concerned about the ecological impacts on wildlife habitat from harvesting wood wastes and residues	1☐ 2☐ 3☐ 4☐ 5☐
Other (please explain) ________________________ ______________________________	1☐ 2☐ 3☐ 4☐ 5☐

9

PART 3: YOUR PERSONAL INFORMATION

Next we would like to ask you a few questions about yourself. All information will be kept CONFIDENTIAL. These questions will help us understand the diverse population of landowners in Lee County.

26. Please indicate if you are a member of any of the following organizations (mark all that apply):

- ☐ Alabama Farmer Federation
- ☐ Alabama Treasure Forest Association
- ☐ Alabama Forestry Association
- ☐ Alabama Loggers Council
- ☐ Alabama Forestry Cooperative
- ☐ Hunting/Recreation Organizations
- ☐ Conservation/Environmental Organizations
- ☐ None
- ☐ Other similar (please identify)________________________________

____

____

27. Please indicate if you participated in meetings/workshops sponsored by any of the following organizations in the past two years (mark all that apply):

- ☐ Alabama Farmer Federation
- ☐ Alabama Treasure Forest Association
- ☐ Alabama Forestry Association
- ☐ Alabama Forestry Commission
- ☐ Alabama Loggers Council
- ☐ Alabama Forestry Cooperative
- ☐ Forest Stewardship Council (FSC)
- ☐ Alabama Cooperative Extension System
- ☐ Forest Service
- ☐ Natural Resources Conservation Services (NRCS)
- ☐ None
- ☐ Other similar (please identify)________________________________

____

____

28. Please indicate your age:

- ☐ 19-29 years old
- ☐ 30-39 years old
- ☐ 40-49 years old
- ☐ 50-59 years old
- ☐ 60-69 years old
- ☐ 70 years old or more

29. You are:

- ☐ Female
- ☐ Male

30. You are:

- ☐ White or Caucasian
- ☐ Black or African American
- ☐ Hispanic or Latino (a)
- ☐ Other (please explain) ______________________________

31. Please indicate the amount of your annual household income (in dollars):

- ☐ $40,000, or less
- ☐ Over $40,000, less than $60,000
- ☐ Over $60,000, less than $80,000
- ☐ Over $80,000 less than $100,000
- ☐ Over $100,000

32. Please estimate the percentage of your household income (10 year average) that comes from logging or any other activity related to the forest land you own and/or lease in Lee County:

- ☐ None
- ☐ Less than 25%
- ☐ More than 25% but less than 50%
- ☐ More than 50% but less than 75%
- ☐ More than 75%

33. The highest level of formal education you received is:

- ☐ Less than high school
- ☐ High school or GED
- ☐ Some college or university
- ☐ Associates degree
- ☐ Bachelors degree
- ☐ Post-graduate degree

Thank you for taking the time to complete this questionnaire. Your cooperation is greatly appreciated. If you would like to receive a copy of the survey result please write your address on the outside of the return envelop.

Comments or suggestions: