BARKING UP THE RIGHT TREE: A SOCIAL ASSESSMENT OF WOOD TO LIQUID BIOFUELS STAKEHOLDERS IN THE PACIFIC NORTHWEST

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Authorization to Submit Dissertation

This dissertation of Jillian Marotz Moroney, submitted for the degree of Doctorate of Philosophy with a Major in Environmental Science and titled " Barking Up The Right Tree: A Social Assessment of Wood to Liquid Biofuels Stakeholders in the Pacific Northwest," has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

With mounting scientific evidence confirming anthropogenic impacts on global climate change, the drive to develop renewable energy sources in order to reduce CO2 emissions is growing. The Northwest Advanced Renewables Alliance (NARA) is a regional public/private consortium in the Northwestern U.S. examining the feasibility of a wood-based liquid biofuels industry. Significant resources have been devoted to investigating the environmental and economic viability of the wood to biofuels supply chain. However, there has been limited research assessing the knowledge, opinions, and perceptions of stakeholders about using woody biomass as a source for biofuels. To address these gaps, we conducted a survey with stakeholders who had a vested interest in woody biofuels in the Northwest. Most survey participants showed a high level of support in general for biomass activities in their region, but show statistically significant differences between support for various forms of feedstock by stakeholder groups. Statistical analysis showed that environmental worries and perceived benefits both affect the potential level of support for a wood based biofuel supply chain in this region. Respondents were worried about forest conditions, especially current excess fuel loads; thought that the regional economy would benefit from collecting forest residuals and that removing woody biomass would produce healthier tree stands; and were worried about the negative impacts of a wood-based biofuels industry related to soil degradation, loss of organic material, and loss of wildlife habitat. The survey results also showed stakeholders who feel they know more about using woody biomass to produce liquid biofuels are more supportive of various aspects of the wood to liquid biofuels industry. This information can be used to create and tailor outreach efforts to better target stakeholders that have concerns, worries, and knowledge gaps through the information outlets that are most meaningful and effective to them.

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Dedication

To Owen and Gus and my amazing family.

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Chapter 1: Introduction

Mounting scientific evidence shows the effects of a warming climate are apparent across species and ecosystems on every continent worldwide resulting in climate change becoming widely recognized as a fact around the world (U.S. Global Change Research Program, 2009). This increase in temperature is associated with increasing concentrations of heat-trapping greenhouse gases (GHGs), the most significant being carbon dioxide (CO2), which is the main offender in temperature rise over the last 50 years (Intergovernmental Panel on Climate Change, 2013; Malmsheimer et al., 2008; U.S. Global Change Research Program, 2009). Multiple scientific models concur that this change is largely influenced by human activity, such as fossil fuel use and deforestation, and that the rapidly rising temperature trend will not be slowing anytime soon, especially without modification of human actions (Intergovernmental Panel on Climate Change, 2013; Hannah, 2011). In light of these discoveries, research has turned to developing technologies which can mitigate global warming by reducing CO2 generated from human use of fossil fuels by replacing them with biofuels. One source of biofuel that shows great potential for practical use is woody biomass from forest residues, which can be used for a variety of energy uses including aviation fuel. In order to understand how a sustainable biomass to biofuel supply chain can operate successfully in the Pacific Northwest, it is necessary to look at key economic, environmental, and social factors (Martinkus et al., 2014; Rosch & Kaltschmitt, 1999; Upham, 2009a; Walker, 1995).

In addition to models which have been developed to evaluate the environmental impacts of using woody biomass as a source for biofuels (Meng & et al., 2003), economic modeling is also used to tease out the benefits and costs of utilizing woody biomass as a fuel source. Despite the ecological benefits of using woody biomass, many studies suggest that the ultimate driver behind a wood-based biofuels industry becoming established and successful lies in the economic aspects and whether the fuel can be economically competitive with other types of fuels (Bright et al., 2010; Obersteiner et al., 2006). One of the largest challenges in removing woody biomass from forests is the large expenditures it takes to get it out of the forest and the fact that there is little or no economic return because of the low commercial value of the material (Patton-Mallory, 2008). Models suggest that as markets develop for

these now waste products, economic incentives to bring them out of the woods will help to ease costs that many land management agencies face today, and increase the use of woody biomass as a fuel source. Obersteiner's model predicts that as the price of carbon emissions goes up in the United States and the world, lower emissions fuel or renewable fuels such as those derived from woody biomass will become more desirable. This would cause an increase in demand resulting in more forests being managed for woody biomass production in addition to an increase of aforestation (planting forests where historically they have not grown) in the form of energy crops (Obersteiner et al., 2006).

Although bioenergy from woody biomass shows great potential as a substitute for fossil fuels in the attempt to mitigate climate change, there are potential limitations to utilizing woody biomass for fuel. For example, wood and forestry resources are not evenly distributed across the United States, much less the world (Favero & Massetti, 2013, Obersteiner et al., 2006). This means that energy from woody biomass is not right for every location. When determining if it is a feasible solution the supply and cost of transport as well as the source of the feedstock must be considered to determine if woody biomass is a good fit (Olszowy, 2011). In the United States, the Pacific Northwest shows considerable potential for utilizing forest residuals from harvesting and restoration treatments in addition to mill residues and construction waste (White, 2010, Obersteiner et al., 2006).

Additionally, biofuels have been recognized by several large fuel consumers as a way to meet their renewable energy goals and improve their environmental practices. In order to mitigate climate change, reduce carbon emissions, and revitalize rural economies, the US Government has established biofuels goals in an attempt to comply with renewable fuel standards set by the EPA as part of the Energy Independence and Security Act ("H.R. 6(110th): Energy Independence and Security Act of 2007," 2007; US Department of Agriculture, 2010). The Energy Independence and Security Act aims to move the US towards energy independence and security by increasing production of renewable fuels and improving the Federal Government's energy performance. In the *USDA Biofuels Strategic Production Report*, woody biomass from forest residues is specifically listed as a source of biomass, which should be explored. The US Air Force has recently identified carbon emissions reduction and renewable fuels security as goals in their energy plan, and as the single largest government aviation fuel

consumer, the US Air Force's need for renewable fuel may indicate a high demand for biofuels in their future (The Assistant Secretary of the Air Force for Installations Environment and Logistic, 2010). The US Air Force is not the only large fuel consumer that is interested in alternative fuels. In their 2009 environment report, Alaska Airlines identified alternative fuels as an opportunity they would like to take advantage of in the future and mentioned their participation in projects which develop, test, and ultimately commercialize alternative fuels for use by airlines (Alaska Air Group, 2009). The interest that the US Air Force and Alaska Airlines have shown in alternative fuels is a strong indicator that there will be increased future demand for renewable biofuels.

To address the growing demand for research in the area of renewable biofuels, Washington State University was awarded a $40 million grant by the USDA in 2011 to fund the Northwest Advanced Renewables Alliance (NARA), a project which aims to determine the economic, environmental and social feasibility of starting a wood-to-jet fuel supply chain in the Pacific Northwest. NARA is a collaboration of private industries and educational institutions working to develop, research, and disseminate information about using woody biomass in the Pacific Northwest for aviation biofuels. The goal of the project is to identify a supply chain for aviation biofuels in the four state region of Washington, Oregon, Idaho, and Montana. Specifically, NARA is looking at utilizing currently unused byproducts of the lumber and timber industries, construction and demolition waste, and both routine and fire-thinning forestry residues as feedstock for isobutanol production. The USDA selected the Pacific Northwest because of its abundant natural resources and the existing infrastructure that can be used in the harvesting and transportation of the raw materials for the production of isobutanol.

Significant time and resources have been devoted to developing models that evaluate scientific, environmental, and economical aspects of the wood to biofuels supply chain both by NARA and other research initiatives. However for a sustainable wood-based liquid biofuels industry to thrive in the Pacific Northwest, it is necessary to also examine its social acceptability. In particular it is important to ask key questions about stakeholder perceptions, knowledge, and potential acceptance or rejection of this industry on a local, state, and regional level (Chin et al., 2013; Zoellner et al., 2008). Ultimately these stakeholders will be the ones employed in the industry, utilizing the fuel, and defining forest health for their region

(Buchholz et al., 2007; Raffa et al., 2009). Despite the fact that the raw materials to support a woody biomass to aviation fuel supply chain are present in much of the Pacific Northwest, there are other factors that will affect the potential success of woody biomass as a source for fuel in this region such as community support, which is strongly influenced by the knowledge, opinions, and perceptions of its residents concerning woody biomass (Dale et al., 2013; Rosch & Kaltschmitt, 1999; Upreti, 2004).

Research has shown that in many cases the public is supportive of renewable energy (Heiskanen et al., 2008; Qu et al., 2011). Some variation has been seen in the types of energy projects that are supported, but often times it is not necessarily the technology that is accepted or rejected, but the way the technology or project is introduced to a community and in what context it fits or clashes with existing local politics, geography, history, and institutions (Heiskanen, et al., 2008). While the West in general has varying politics and geography, one common denominator in this region is the large expanses of federally owned land, and strong feelings relating to recreating in, utilizing, and managing the natural environment. The rural West has grown in the past 40 years, and the main reasons cited by those relocating from more urban areas are social environment, environmental quality and amenities, and recreation opportunities (Rudzitis, 1980). In addition, concern about environmental factors such as wildlife, fish, wilderness, and recreation has increased substantially since the 1960s (Steel et al., 1994). Because of the high value placed on physical environment, it is not surprising that newcomers and long time residents in the West also care a great deal about the management of federally owned land in their regions. Research indicates that residents of the Pacific Northwest have strong feelings about where and what type of timber harvests should take place and generally are against clear cutting of forests (Hansis, 1995; Ribe, 2006). Research also indicates people prefer protective management strategies over commodity based management strategies, both in the Pacific Northwest and in the nation as a whole (Rudzitis, 1980; Steel et al., 1994).

To date there has only been limited research conducted assessing the knowledge, opinions, and perceptions of stakeholders regarding using woody biomass as a source for aviation biofuels, how they vary by region and stakeholder group, and what affect these factors have on the social acceptability of a biofuels supply chain. This is an important area of study

because lack of support and public perception have been cited as the main obstacles which can hinder the success of a biofuels operation (Rosch & Kaltschmitt, 1999; Upham, 2009a; Walker, 1995). Studies indicate that opinions regarding the use of biomass will vary between those growing or harvesting the fuel source and environmentalists (Peelle, 2001). It has also been hypothesized that different stakeholders will have varying concerns and perceive different benefits from utilizing woody biomass (Benjamin et al., 2009; Peelle, 2001). One of the major hurdles identified to gaining stakeholder support is the limited information and knowledge base that stakeholders have regarding woody biomass (Mayfield et al., 2007; Peelle, 2001; Qu et al., 2011). An important step in gaining support for this emerging industry will be identifying the knowledge gaps and finding ways to communicate information to a variety of stakeholder groups (Mayfield et al., 2007; Peelle, 2001; Upreti & van der Horst, 2004).

In order to address these gaps in the literature, this research evaluates a variety of stakeholders in the Pacific Northwest in order to determine their knowledge, opinions, and perceptions of using woody biomass for bioenergy and biofuels production. From this evaluation we hope to identify areas which will be well suited to support the emerging woody biomass to biofuels supply chain, and also identify knowledge gaps and propose methods of communication to remedy them in order to help more communities understand their potential role in this emerging industry.

Study Goals

There are several research teams working on various aspects of the NARA project. These teams include education, sustainability measurement, feedstock, conversion, and outreach. While each of these teams conduct their own research, their findings are shared and contribute to the overall goal of the project: to build a sustainable wood to aviation biofuels supply chain derived from forest residuals and other wood waste in the Pacific Northwest.

The research presented has relevance to the Sustainability Measurement, Education, and Outreach teams. This project contributes to the work of the Sustainability Measurement team through helping to understand the social acceptability of the project. It also contributes to the overall goals of the Outreach and Education teams by assessing stakeholder opinions

regarding the supply chain, identifying knowledge gaps, and proposing ways to address these gaps.

Research Objectives

Because the Pacific Northwest is a diverse region in terms of biophysical attributes, cultures, and population density, it is assumed that some areas within the region will be better suited to contribute to the biofuels supply chain than other areas. Research is already being done regarding the suitability of infrastructure, availability of feedstock (e.g., forest residuals and construction and demolition waste), and economic feasibility. The main focus of this study is the social acceptability of the wood based biofuels industry within the study region. This research looks at the differences among stakeholders in the region to determine their levels of knowledge about, and acceptability of, the wood-based biofuels industry and how it varies across the region and by demographics. The specific research objectives are to:

- Identify key differences in knowledge and opinions regarding the acceptability of an emerging wood based biofuels program by stakeholder group, political affiliation, knowledge level, state, and region.
- Compare knowledge levels of stakeholders in order to determine which demographic groups are lacking information about specific topics related to the development of a wood-based biofuels industry in the Pacific Northwest.
- Determine the best ways to communicate with stakeholders to address the gap between groups of stakeholders that hold significantly different perspectives on the biofuels industry and to increase the social acceptability of a wood based biofuels industry.
- Use the above information to identify which factors predict high levels of support for a biofuels operations and participation in a wood-based biofuels industry.

Research Questions

This research informs three manuscripts that will be submitted to peer reviewed journals. Each journal article will explore aspects of the following questions:

1) What differences in knowledge, perceptions, and opinions do we see between stakeholder groups (SHG), demographic factors, and by region? Specifically, what

relationship exists between stakeholders' perceived level of knowledge and the social acceptability of a wood based biofuels supply chain?

Hypothesis 1.1: Opinions will vary by SHG, region, and other demographic factors, specifically political affiliation.

Hypothesis 1.2: Concerns/worries will vary by SHG, region, and demographic factors.

Hypothesis 1.3: Communities with a perceived high level of knowledge about biofuels will be the most supportive of a biofuels supply chain, have less worries, and better understand the possible benefits of harvesting biomass.

2) What knowledge gaps exist among different SHG and how can these be addressed in order to increase stakeholder support?

Hypothesis 2.1: Perceived knowledge levels will vary by SHG, region, and state.

Hypothesis 2.2: Outreach efforts should vary depending on SHG.

Theoretical Perspectives

Communicative Planning Theory

In order to gather information about the social and cultural structures that exist within my research area, I am relying heavily on communicative planning theory because it casts local stakeholders in the role of experts about their own region, lifestyle, and values. This theory is two-fold: first it emphasizes two-way communication between planners and stakeholders, and second it recognizes that there are multiple ways of knowing, valuing, and giving meaning. This second part is particularly important to this study as multiple stakeholder groups will be included. The theory also emphasizes the importance of a dynamic research process that can

be adjusted as stakeholder input is received. This theory is highly applicable when any sort of policy or industry decisions must be made at a community level (Healey, 2003).

For much of planning history, especially post World War II era planning, there has been a "one size fits all" school of thought where planners, many times unfamiliar with the specifics of a community, have tried to replicate plans which were successful in other areas. While this was usually well intentioned, it often times limited communities' potential, fell short in fulfilling their needs, or ignored their concerns and visions completely. Rational planning was used in the 1960s and 1970s to focus on specific problems and find solutions through a logical, well defined process (Healey, 2003). From this process grew a better understanding of both regional economics and the structural dynamics of economic and political relations, in other words, planning began to acknowledge the affect that cities have on their local environment, and that there are existing political and social structures that also have an effect on communities. Planning began to shift from simply assigning material property (who should get what), to understanding and evaluating cultural values of an area, and how these affect the environment. By the late 1980s and early 1990s, planning began using a method which identified problems at a community level and generated solutions which were informed by local norms and values and emphasize a dialog based approach (Healey, 2003; Lawrence, 2000). This new wave of thinking, known as communicative planning, aims to identify problems through public input on a community level, then to generate solutions collaboratively based on community interests, values, norms, and reasoning. A key element of the theory is that research is informed through a communicative approach- essentially allowing research to be somewhat dynamic by letting the local experts and stakeholders share and ask question throughout the research process. Communicative planning theory will enrich my research by placing the focus on recognizing and understanding the problems identified by many different stakeholder groups in regards to introducing a wood to biofuel supply chain in their region.

In many areas, people have an in-depth understanding of the issues that their community faces because of their deep roots there. Communicative planning recognizes a range of ways of knowing, valuing, and giving meaning; and understands that this range will vary by location. Healy’s approach takes into account the spatial demographic of acceptance by acknowledging

that there are existing politics and norms in a community that vary by region. Having multiple stakeholders involved in the surveying process attempts to paint a more clear picture of the specific needs and influences in a community (Healey, 2003). This is a crucial component when identifying any spatial trends involving knowledge, perceptions, and opinions.

When research questions and hypothesis were being formulated for this study, the underlying concepts of communicative planning, especially the idea that values and norms vary regionally, by community, and by stakeholder group, were considered. With this in mind, questions that considered specific differences in opinions demographically, between stakeholder groups, and by region were generated.

Communicative planning looks at what is valued about a local environment, how these values might be threatened, what specific projects might be successful given community dynamics and values, and who will benefit (Healey, 2003). Subscribing to a theory that emphasizes understanding the underlying social structure and attitudes of an area focuses this research on stakeholder input.

Value-Belief-Norm Theory

In addition to understanding a community's values exhibited through individuals' attitudes and opinions it is equally important for this study to understand how these values will affect the support and acceptance of a new biofuels industry in a region, and this is a reason why I will also be subscribing to the Value-Belief-Norm Theory (VBN). VBN aids in understanding how levels of social acceptance may vary. VBN theory says that the adoption of conservation behavior is dictated by an individual's societal norms, personal values and beliefs. An individual's personal norms are determined by their awareness of positive consequences of their actions and responsibilities (Stern, 2000; Upham, 2009a). This directly affects behavior, which is carried out because of a feeling of obligation. For example, environmental actions are more likely to be taken when a person is aware of the consequences that the action will have, and when an individual feels responsible for causing or preventing these consequences (Ibtissem, 2010; Stern, 2000). An individual faces an internal conflict when they feel that respecting societal norms will harm their own personal interests, and this is the point where environmental behaviors are either adopted or rejected.

VBN theory identifies elements regarding attitudes and opinions revealed by surveyed individuals, which contribute to the societal norms of a region. Specifically, the theory emphasizes uncovering information that relates to which kinds of things or people will be affected by environmental conditions and projects (e.g., local economy, local forest health, certain stakeholder groups), and if survey participants feel that their individual actions (such as support for siting renewable energy facilities in their community) can alleviate the threats to the identified people and things. For example, individuals may be worried about the local economy of their region and generally supportive of using wood as a source of biofuel, but if they do not feel that siting a facility in their community will actually help the local economy, they may not be supportive of a wood-based biofuels facility in *their* community.

Limited research has been done regarding communities' perceptions about biofuels, bioenergy, renewable fuels, and forests. One study found that people living in communities that produce ethanol said that jobs were one benefit of the renewable fuel, but felt vulnerable when it came to the impacts that future industry declines would have on their community (Selfa et al., 2011). Other studies have found that people in the Pacific Northwest value their local forests for recreation and environmental quality and that these values manifest themselves in a general opposition to clear cutting (Hansis, 1995; Rudzitis, 1980; Steel et al., 1994). How will the values and beliefs of people in the Pacific Northwest mesh with the harvesting and utilization of woody biomass for biofuels?

Surveying will produce results that illuminate some elements identified as important by the VBN theory, but will also identify areas that may need to be explored further through face-to-face interviews with stakeholders. Survey responses will get at the epicenter of who and what stakeholders think will be affected by a wood based biofuels industry, if they think that participating in this industry will directly affect their communities, and what strategies will be most affective towards changing attitudes and behaviors

Conceptual Framework

Two frameworks were conceptualized in order to organize and isolate contributing factors, identified by the theories and previous literature, that may explain the social acceptability of a wood-based liquid biofuels industry in the Pacific Northwest. Inputs were identified that have the potential for influencing perception and opinions. The right combination of positive

perceptions and opinions, the knowledge base of an area, and the raw material and infrastructure present can affect the overall social support of a liquid biofuels industry (Benjamin et al., 2009; Fürstenau et al., 2006; Gericke & Sullivan, 1994; Peelle, 2001; Popp et al., 2011; Upham, 2009a; van der Horst & Vermeylen, 2011).

The first conceptual framework considers how stakeholder group, demographics, and community context are linked to opinions, worries, and knowledge of individuals about using woody biomass as a feedstock for liquid biofuel (Figure 1).

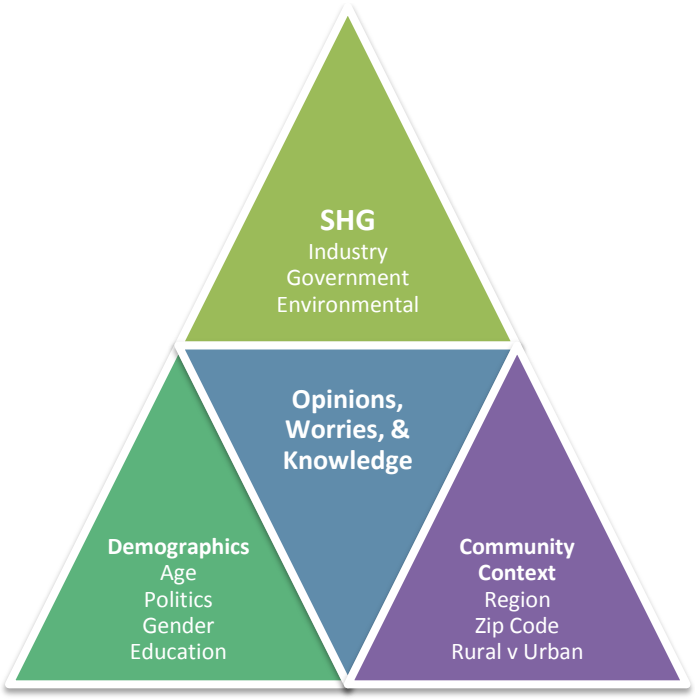

Figure 1: Opinions, Worries, and Knowledge- The conceptual framework breaks down information gathered through survey by stakeholder group (SHG), demographics, and community context to determine trends in opinions, worries, and knowledge.

The second framework examines how demographic group, community context, knowledge level, and worries will all shape outreach efforts made to increase the social acceptance of a wood-based liquid biofuels industry on a regional, state, or county level. We believe that remedying knowledge gaps through outreach and communication efforts adapted to specific situations has the potential to enhance social acceptance (Figure 2).

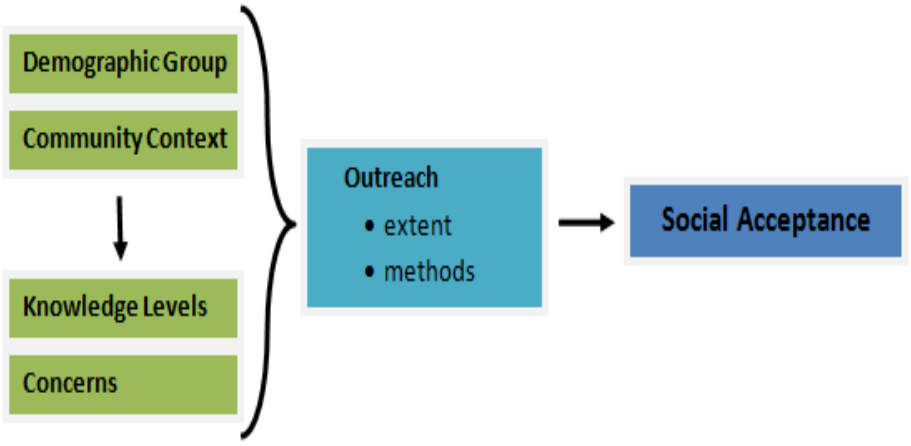

Figure 2: Social Acceptance of a Liquid Biofuels Industry- Demographic information, community context, knowledge level, and worries, can be used to identify which outreach efforts are necessary to increase the social acceptability of the liquid biofuels industry. Communication is predicted to be a means through which knowledge can be enhanced in order to increase acceptance.

Perception/Opinion

I examined perceptions and opinions in several broad categories, with the goal of identifying differences in opinions about what is socially acceptable based on stakeholder groups, demographic categories and community context. Perceptions are impacted by education, experience, knowledge, values, beliefs, social background and identification with the community. Perceptions impact whether or not there is support. Support is also affected by communication, trust, environmental concerns, local community impact and knowledge, experience and education (Benjamin et al., 2009; Fürstenau et al., 2006; Gericke & Sullivan, 1994; Peelle, 2001; Popp et al., 2011; Upham, 2009b; van der Horst & Vermeylen, 2011).

Stakeholder group

The stakeholder groups looked at are Industry, Conservation/Tribal, Local Interests, and State/Federal Government. These groups were identified not only because they are the key economic players and have a stake in creating policy, managing resources, and operating a

wood based biofuels supply chain, but also because recent literature cites these groups as having strong and sometimes opposing opinions about using woody biomass as a fuel source (Benjamin et al., 2009; Berninger et al., 2010; Fürstenau et al., 2006; Peelle, 2001). In her 2001 study Peelle found that support or opposition for biofuels was strongly tied to stakeholder group and ultimately whether the stakeholder would directly or indirectly make a living from the biofuels industry (Peelle, 2001). This study compared farmer and environmental group views on agricultural biofuels and found support and hesitations within both groups, but for different reasons. In general, those involved in the agricultural industry focused on immediate economic gains, while environmental groups' support was more conditional depending on the type and use of biofuel. At the time, the study found that differences in the two stakeholder groups were greater than their similarities, especially regarding combustion as an acceptable conversion process. Agreement was found regarding more general concepts including conserving resources, environmental concern, and the value of sustainability (Peelle, 2001). Similarly, Benjamin et al. predicts that opinions and perceptions will vary by stakeholder group. Different stakeholder groups may face a variety of concerns including economic, environmental, and logistic related to biofuels, and forest resources (Benjamin et al., 2009; Berninger et al., 2010). Fürstenau et al. found that while stakeholder groups may have similar objectives when it comes to forest use, the ranking of importance or priority of these objectives varies (Fürstenau et al., 2006).

Demographics

Demographic variables considered include age, gender, and level of education. These variables were selected because of their clear ties to stakeholder opinions about biomass and forest resources exhibited in existing literature (Qu et al., 2011; Steel et al., 1994; Upham, 2009a). In addition to these categories, stakeholder political preference was assessed because the tie between political inclination and support for woody biomass has not been explored in depth in the literature. When discussing environmental attitudes and behaviors, Upham points to demographics as factors that influence environmental attitudes regarding renewable fuels (Upham, 2009a). Qu et al. found differences in the types of bioenergy supported by females compared to those supported by males, and that male respondents were generally more knowledgeable about renewable energy than female respondents (2011). Another study found that younger people, women, and liberals are more likely to have biocentric orientations when

it comes to forest management as opposed to older people, men, and conservatives who had more anthropocentric (Steel et al., 1994). The study also found that more highly educated individuals in Oregon were more likely to have biocentric views than their less formally educated counterparts (Steel et al., 1994).

Community Context

For this study it is important to explore what affect the community context (any geographic or spatial circumstance) may have on stakeholder support of woody biomass. The literature indicates that spatial elements such as proximity to the resource, rural vs urban communities, and proximity to proposed projects all influence project support (Benjamin et al., 2009; Berninger et al., 2010; Gericke & Sullivan, 1994; van der Horst, 2007). It is quite likely that rural areas with economies based in the forestry industry might be more supportive than urban areas that are more ecologically conscious and may be more concerned about environmental tradeoffs. Additionally, it is likely that residents that live closer to areas suited for facility siting may be more strongly opposed to the siting of certain facilities (Benjamin et al., 2009; van der Horst, 2007). Similarly, people living closer to the natural resource often times have opinions that differ from those who do not live near the natural resource when it comes to how the resource should be managed or used (Gericke & Sullivan, 1994). Qu et al. (2011) found differences in terms of knowledge and support for different renewable energy sources based on whether survey participants were from rural or urban areas.

Knowledge

Previous research indicates that the level of knowledge stakeholders perceive themselves to have influences their level of support for biofuels industries. The more knowledgeable stakeholders feel, the more confident they are in making informed decisions relating to biofuels. One of the greatest frustrations felt by stakeholders is that their questions and concerns are not being addressed, which then results in loss of support for biofuels industries. Several studies suggest that open communication and more available information about biofuels can increase support for projects.

Peelle (2001) named knowledge gaps as one reason for the variation in stakeholder opinions. The study found that large knowledge gaps exist in the realm of public information on biomass, and both agricultural industry stakeholders and environmental stakeholders

requested more information on various aspects of industry environmental impacts, sustainability, net benefit evaluations, and conversion processes. The study also found that "some of the least sustainable examples of biomass (e.g., mixed solid waste, ethanol from corn kernels) have come to represent the whole of bioenergy for many environmental stakeholders" (Peelle 2001, 11). This results in uncertainties that may weaken support (Peelle, 2001). Qu et al. found that college aged students in China showed stronger support for renewable energy sources which they knew more about, but expressed interest in learning more about the sources which they knew less, such as woody biomass (2011). The lack of knowledge about the environmental impacts of removing woody biomass from the woods has been identified as one potential obstacle when gaining public support for using woody biomass and this, combined with general unawareness of the benefits of using woody biomass, strongly influences the public's perception (Mayfield et al., 2007; Rosch & Kaltschmitt, 1999).

Communication/Education

One way to remedy knowledge gaps is to improve communication between stakeholder groups, the biofuels industry, and scientists involved in research and development. Multiple ideas and visions about bioenergy could benefit from open discussion and comparison on numerous levels including scientific, production, and policy. Peelle (2001) sites silence and lack of answers as an issue, which has potentially resulted in lost supporters from multiple stakeholder groups. The study also explains that stakeholders may become frustrated or lose interest in wood-based biofuels when their inquiries are ignored or remain unanswered. Studies suggest that opening communication with stakeholders as well as the general public is a necessary step in creating a positive atmosphere and a well informed community, both of which are essential to the success of a bioenergy facility (Heiskanen et al., 2008; Mayfield et al., 2007; Monroe & Oxarart, 2010; Peelle, 2001). In addition to providing more information to stakeholders, studies suggest redefining the way information is communicated by engaging deliberative communication strategies between the government and the public, instead of treating stakeholders as passive receptacles of information (Owens & Driffill, 2008; Upreti & van der Horst, 2004). Research relevant to the NARA project, which is looking at converting woody biomass into biojet fuel, has found lack of information about woody biomass available to legislators and the general public as a potential barrier and suggest that policy makers,

utilities, and other parties involved in the industry should be targets of educational attempts to inform stakeholders of the benefits of using woody biomass (Kraxner et al., 2009; Mayfield et al., 2007; Rosch & Kaltschmitt, 1999). Using education to address these issues will strongly contribute to success in the biofuels industry (Mayfield et al., 2007).

Project Success

In theory, communities can be identified with the right combination of knowledge, perceptions, and physical capital, which not only are rich in the raw materials required for a biofuels industry, but also are socially ready to accept and support biofuels projects within their own communities. By evaluating these elements early in the planning process, ongoing research and possible investors will be able to focus on communities that are ready, and communities will have access to the necessary information and communication pathways to inform and adapt the project to suit their community (Heiskanen et al., 2008). Qu et al. (2011) emphasizes that understanding the public's perceptions, attitudes, and knowledge is essential in creating successful policy for utilizing bioenergy. Community involvement in project conceptions not only improves stakeholders knowledge of projects, but also their support and success (Gericke & Sullivan, 1994; Heiskanen et al., 2008; Walker & Devine-Wright, 2008; Wolsink, 2007).

Methodology

A mixed methods survey was used to ask key questions about stakeholders who had vested interest in woody biofuels opinions and perceived knowledge regarding a woody biomass to biojet fuel supply chain. The multi-phased survey of individuals in Idaho, Montana, Washington, and Oregon covered various topics related to woody biomass, biojet fuel, and feedstock collection and utilization. Collecting both quantitative and qualitative data in the survey was necessary for this research to paint a broad picture of the opinions shaping the social acceptability of a wood based biofuels industry in the Pacific Northwest (Adams St. Pierre, 2009; Leedy, 1997; Lichtman, 2011; Marshall & Rossman, 2011).

Survey Development[1]

Prior research studies addressing topics related to biomass to bioenergy issues were used to guide development of the survey instrument used in stage 1 (Adams et al., 2011; Becker & McCaffrey, 2011; Clement & Cheng, 2011; Davenport et al., 2007; Halder et al., 2010; Halder, 2011; Mayfield et al., 2007; Monroe & Oxarart, 2010; Nelson, 2005; Stidham & Simon-Brown, 2011; Upham et al., 2007). The studies utilized a variety of quantitative and qualitative measures such as multiple choice or scaling questions in addition to open ended, less structured questions. Some of the salient issues in prior research include regional combined heat and power plants, utilization of forest materials, facility siting, social acceptance, forest management perceptions, bioenergy perceptions, trust, communication, local community impact and environmental concerns.

The development of an industry that converts forest biomass to biojet fuel is a new, emerging exploratory and emerging topic. Thus, it was important to include open-ended questions in the survey instrument (Creswell 2009, 2013). However, some themes relevant to the topic (e.g. knowledge, communication) have been addressed in prior research and are more aptly studied using closed-ended question types (Creswell 2009, 2013). The mixed methods survey instrument examines stakeholders with a vested interest in woody biofuels perceptions and includes preliminary qualitative and quantitative observations regarding the social factors which impact a biomass-to-biojet industry based on forest residues in the Pacific Northwest. Key issues investigated in the survey included forest management practices, trust, communication, knowledge, experience, social support, local community impact, and environmental concerns.

In order to ensure that every participant was interpreting each question in the same manner and able to respond accurately, the survey instrument was reviewed by multiple other USDA-NIFA Agricultural and Food Research Initiative grant researchers and then piloted with 10 stakeholders who had a vested interest in woody biofuels. These stakeholders were interviewed (surveyed) in person. Feedback from these ten structured interviews was used to further refine the survey questionnaire.

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[1] This section relied heavily on reports produced for NARA by Katie Gagnon.

Accounting for Survey Errors

In survey research today there are a wide variety of survey goals, subjects, and methods, but there are four essential elements, referred to as the "cornerstones" of survey research, that must be solid and high quality in order to ensure a survey can accurately measure and represent intended constructs, which is known as the survey specification (Leeuw et al., 2008). Before a survey instrument was developed, it was important to determine the research objective and define a list of key questions we were hoping to answer through the information generated from the survey (Dillman, 2000; Leeuw et al., 2008). Once this was completed, the four cornerstones (coverage, sampling, response, and measurement) were identified and ways to minimize errors in each category were identified.

Sample Selection Methodology

Identifying Stakeholder Groups

My research is focused on potential NARA supply chain stakeholders (SH) who have a vested interest in the woody biofuels industry and therefore will be relatively informed regarding one or more critical elements within the biomass-to-biojet industry supply chain concept. The wood-based biofuels supply chain involves activities from harvesting of the feedstock to transportation by one or several modes, mechanical size reduction and densification, pretreatment, conversion, refining, and final biofuels delivery to consumers at regional airports. This project focuses on feedstock through pre-conversion and conversion. Marketing and distribution research is being completed by another NARA research team.

Development of the SH group list began with SH groups utilized in prior research. For reference, the groups used by Mayfield et al (2007) were renewable energy, economic development, forest management, and the forest products industry. Becker et al (2011) defined the SH groups as federal, state, tribal, and local government staff; loggers; manufacturers; community leaders; and environmentalists. Lastly, the SH groups used by Stidham and Simon-Brown (2011) were community organizations, conservation organizations, elected officials (staff of), energy utilities, federal agencies, forest industry sector, informed energy participants, state agencies, and tribal organizations.

The initial list of stakeholder categories was 21, which generally were informed by career or organization affiliation. These 21 groups were consolidated into three larger categories: Government, Industry, and Environmental, based solely on assumed similarities. However, after data analysis began, it became clear that this assumption was mistaken due to the wide range of responses within the three broad categories. The initial 21 stakeholder groups were reviewed for similarities in the means of their answers to key questions in order to divide them into four groups that had greater consistency between respondent answers within each group. These four final groups are categorized using similarities in survey answers, career and organization information, and operation level (local vs regional). The final four stakeholder groups in my sample frame are:

1. Industry
2. Conservation/Tribal
3. Local Interests
4. State/Federal Government

The 21 stakeholder categories that make up the larger broad groups are shown in Table 1.

Table 1: Stakeholder Categories

Industry	Conservation/Tribal	Local Interest	Federal/State Gov.
Forest Industry	Tribal Members	University Extension	Academic Researchers
Non-Industrial Land Owners	ENGOs	Economic/Business Development	Extension Foresters
Private Foresters	Local Resource Managers	Interested Local Businesses/Investors	State Foresters
Industrial Landowners	Wilderness Outfitters/Recreation	City/Town Elected Officials	State and Federal Scientists
Harvesters/Haulers		County Elected Officials	State and Federal Natural Resource Managers
Secondary/Primary/Paper Products			District Rangers

Sample Acquisition and Selection of Potential Stakeholder Interviewees

The purpose of our research is to understand the perspectives of a broad range of vested interests. Purposive sampling using maximum variation was employed (Miles & Huberman,

1994; Patton, 2002). Potential SHs were obtained from several different sources including NARA meetings, NARA website registration, Outreach Team members, the list of Northwest Environmental Forum participants (which also discusses forest and bioenergy issues in the Pacific Northwest), and SH suggested from local economic developers from all NARA regions.

The lists contained 917 potential SHs before they were reviewed for duplication of individual names within and between the lists. When possible, the individual's current place of employment was verified online. Of those 917, 41 were outside NARA's 4-state region leaving 873 potential SHs to survey.

Each potential SH was assigned a "touch point code" (TPC) based on the type of acquisition (O=outreach recommendation or N=not an outreach recommendation) and the number of source lists in which the individual had been included. The list was separated into the 10 geographic boundaries. From there, a detailed and methodical process was utilized to ensure a wide range of SH groups.

Data Collection

The four-state region was divided into potential supply chain areas by the NARA Outreach team. These areas include the Western Montana Corridor, the Mid-Cascade to Pacific region and the Columbia Plateau. We used these areas to target our survey populations. Using a mixed mode design that included both internet and mail surveys, we completed several phases of surveying (Dillman, 2000). Phase 1 of surveying commenced in March 2013 when the survey was emailed to 151 participants in the Western Montana Corridor (WMC) and 109 participants from the Mid Cascade to Pacific (MC2P) region. Each participant was sent an email which contained a brief introduction to the NARA project, the link to the online survey, and an individual participant code which they were to enter in order to complete the survey (Appendix 1). The participant codes were used to track who completed the survey by stakeholder group and region. After the first week, all participants who had not yet completed the online survey were sent a reminder email with the link to the survey and their participant code (Appendix 2). If they did not complete the online survey by the end of the second week, each participant was contacted via phone. The initial responses from both regions were used for some preliminary analysis, and to further refine and shorten the survey instrument. This

second generation of the survey instrument was used in Phase 2 of the surveying process and was sent out to an even larger population.

The Phase 2 population included additional stakeholders from both the WMC and the MC2P, in addition to incorporating the Columbia Plateau (CP). The CP region, which spans the area between the eastern border of the MC2P to the western border of the WMC, was added as part of collaborative effort between the NARA Stakeholder Assessment group and the U of I Wood-Based Biofuels Project, a project also funded by a USDA grant. The Wood-Based Biofuels Project aims to evaluate socioeconomic impacts of wood-based biofuels development strategies on northern Rocky Mountain communities in the Northwest by gathering input from regional stakeholders in addition to doing economic modeling. The Wood-Based Biofuels Project agreed to use the NARA survey, and through these combined efforts and funds, both projects were able to expand their research areas to cover the entire Pacific Northwest.

Phase 2 of the surveying process began in July 2013 using a similar email process to Phase 1. During Phase 2, the chance to win one of 12 university sweatshirts was added as an incentive to increase survey response rates. Language was added to the survey invite emails, which indicated the participant's chance to win an embroidered university sweatshirt upon completion of the survey (Appendix 3). At the end of the surveying period, the names of 12 participants were drawn for the 12 university sweatshirts from collaborating NARA universities.

After the first email and the second reminder emails were sent out to Phase 2 participants (Appendix 4), a paper survey was mailed to all Phase 1 and Phase 2 participants who did not complete the survey online (Appendix 5). Approximately one week later a follow up post card was sent as a reminder (Appendix 6).

After the mail surveys were returned, responses from all forms of surveying were reviewed and additional efforts were made to contact stakeholder groups with lower response rates. We worked with Laurel James of the NARA Tribal Partnerships Project to email additional tribal contacts, and Bob Dingenthal, Executive Director of the Gifford Pinchot Task Force, for additional environmental contacts. The stakeholders suggested by both Laurel and Bob were

contacted via email with the survey link, then a reminder was sent to stakeholders who had not yet taken the survey.

The surveying process concluded in November 2013.

Population, Sampling, Constructs, and Protocols

As of survey completion in November 2013, the overall response rate for all regions was 38%. During Phase 1 of surveying, 53 out of 151 surveys were completed by stakeholders in the WMC, and 19 out of 109 surveys were completed by MC2P stakeholders. During Phase 2 of surveying, 13 out of 59 surveys were completed by WMC stakeholders, 68 out of 158 surveys were completed by MC2P stakeholders, and 91 out of 391 surveys were completed by CP stakeholders. During Phase 3 of the surveying process, 610 paper surveys were sent to all non-respondents from all regions. Eighty surveys were completed as a result of these mailings. Figure 3 shows response rates for all three phases. After re-categorizing survey participants from the original three broad stakeholder groups to the four broad stakeholder groups, 298 surveys (a 34% response rate) were kept and used for the majority of data analysis.

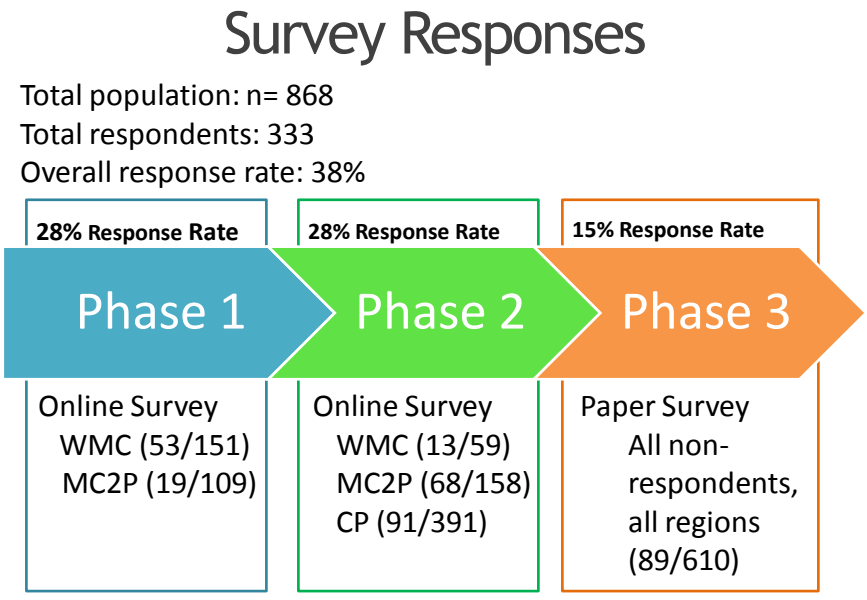

Figure 3: Response rates by phase of surveying process.

A non-response bias test was conducted. Several questions from the final version of the survey were selected and compiled into a short, phone-friendly version of the survey. Phone calls were made to randomly selected individuals who had not yet completed the survey. One stakeholder from each stakeholder group was selected from each of the four state regions for a total of 12 individuals who completed the phone survey. The results generated by the phone surveys were compared to the overall survey results and it was determined that there were no statistically significant differences between the population that took the survey, and those that did not. Comparisons were also made between participants who completed the survey the first time they were contacted via email and participants who completed the survey after several email contact attempts were made, again, no statistical differences were found.

Quantitative Data Analysis

There were several stages of data analysis beginning with descriptive statistics and working up though regression. Statistical Package for the Social Sciences (SPSS) was used to analyze data.

To being, exploratory data analysis (EDA) was used to get a general idea of the dataset, an idea of any anomalies that existed, and an understanding of the limitations of the dataset (Field, 2013; The University of Reading Statistical Services Centre, 2001). Descriptive statistics were used to summarize that data and to gain a better understanding of sampling proportions across strata (politics, education, age, urban vs rural, SHG, etc.). The main issue with the dataset was that the original stakeholder group divisions (industry, environmental, and government) left me with unevenly distributed categories and an excess of "noise" within categories. This problem was resolved through manual entry of new stakeholder categories (Industry, Conservation/Tribal, Local Interests, and State/Federal Government) based on survey participants' jobs, and exclusion of stakeholders whose jobs fell outside of the fields we identified as "vested interests" for whom the survey was written. By adding an additional stakeholder group, survey participants were more evenly distributed across the categories, which also had more consistent survey answers.

In addition to adding another stakeholder group, data was cleaned and edited by inserting additional categories such as NARA Region, Urban vs. Rural, and First Respondents vs. Later

Respondents in order to create a clean, user friendly dataset which was used to compare subgroups in the population.

Factor analysis was used to reduce multi-item measures to single constructs (Table 2). This allowed me to group multiple questions that were measuring the same item into latent factors that were conceptually and statistically grouped based on observed variables in the survey. Four questions were used to determine opinions about feedstock source, five questions to measure opinions about potential uses of woody biomass, six to measure perceived benefits of a woody biomass utilization, and five to measure biomass support. Originally, nine questions were written to measure worry, but because of low internal consistency, these nine questions were divided into four factors which measured environmental concern, economic concern, forest health concern, and concern about U.S. oil dependency.

Table 2: Questions used to measure constructs.

Attitude/Opinion Constructs	Questions
Biofuel Feedstock	I agree/disagree that: • Woody biomass from timber harvesting should be used for bioenergy. • Woody biomass from forest thinning should be used for bioenergy. • Woody biomass from bug infested/diseased trees should be used for bioenergy. • Public forests should be managed for the production of forest products.
Woody Biomass Uses	I agree/disagree woody biomass should be used to supply: • A bioenergy power plant • A wood pellet production plant • A sawmill • A wood products manufacturer (i.e., furniture, interior paneling) • A liquid biofuels refinery
Worry	I am worried/not worried about: • The local economy of my region • Adverse environmental impacts related to woody biomass removal in the PNW • The current direction of forest management practices on public lands in the PNW • Rural Unemployment • Decreasing fossil fuel reserves • Adverse environmental impacts related to liquid biofuels production in the PNW • The ability to find renewable fuel sources • The current condition of forest health in the PNW • U.S. dependence on foreign oil
Perceived Benefits	I agree/disagree: • Increased use of liquid biofuels will off-set climate change. • The biofuels industry could improve the rural economy. • Using biofuels will reduce U.S. dependence on foreign oil. • The biofuels industry will have more benefits than risks for society. • The refineries in my region would provide employment opportunities. • Biofuels have a lower environmental impact than conventional (fossil) fuels.
Supply Chain Support	I support/oppose: • Obtaining woody biomass from public forests in my state • Siting a pre-processing depot facility in my county • Siting a conversion facility in my county • Siting a biofuels refinery in my county • Selling biofuels within the US that are derived from woody biomass

Demographic factors were analyzed to determine optimal groupings. For example, stakeholders were asked their political preference, with seven options. These options were combined in multiple ways in order to see which one has the most explanatory power. Instead of using each unique category, it was most effective to look at differences between moderately/very conservative and moderately/very liberal stakeholders.

The worry questions used a four-point scale rather than a five-point scale in order to eliminate any "fence-sitters" and force survey participants to reveal their true feelings regarding the topic, and because, in this case, an intermediate category would have been non-informative (Asun et al., 2015).

The relationships between variables were mainly explored using ANOVA and MANOVA with univariate analysis with Tukey post-hoc tests to determine significant differences between groups. Demographic information was important for teasing out differences between worry, knowledge, support, and opinion regarding an emerging biofuels industry, and by using ANOVAs I was able to determine where significant differences between means existed.

Regression analysis was used to determine the extent of the relationship between level of support for a wood based biofuels supply chain and worry, perceived benefits, and knowledge. Examination of these predictor variables shed light on how social acceptability is affected by different variables, what proportion of an outcome variable is attributed to each level of a variable, and what is producing variation (Bhattacherjee, 2012; Cohen et al., 2003; Field, 2013). The results were used to test the hypotheses

Qualitative Data Analysis

The answers to qualitative questions asked on the survey were analyzed for content and themes by three different researchers. First, a master list of codes was developed for each open-ended question from the initial reading of a sample of responses. A second researcher independently developed their own list for the same questions, and the two lists were compared and revised in order to ensure consistency of categories (Hruschka et al., 2004). The final list was used to categorize responses ensuring that themes were broken down into unambiguous categories, which could be tallied (The University of Reading Statistical Services Centre, 2001). Next, three coders used these categories to code each participant's response for their perceived benefits, perceived negatives, and their answers about forest conditions. Using Krippendorff's Alpha, an average inter-coder reliability of .90 was achieved for perceived benefits, .76 for perceived negatives, and .81 for forest conditions between the three researchers. The frequencies of different responses were counted and cross-tabulated into relevant bundles for detailed quantitative and non-quantitative analysis in order to

identify trends by stakeholder groups, states, and regions. (Bhattacherjee, 2012; The University of Reading Statistical Services Centre, 2001).

Dissertation Format

The results of this survey are presented in three chapters, that are written as manuscripts to be submitted to academic journals. The first article, included as Chapter 2, is an overview of survey results mainly analyzed quantitatively. This chapter examines Hypothesis 1.1 and Hypothesis 1.2 by identifying survey themes and key differences by stakeholder group, state, and political affiliation. This article also uses regression to determine the relationship between support for biofuel activates and perceived benefits/specific concerns.

The second article, included here as Chapter 3, is a mainly qualitative analysis of open ended survey questions. This article examines Hypothesis 1.1 and Hypothesis 1.2 by looking at themes in stakeholder perceptions about forest health and conditions, perceived benefits, and potential drawbacks of harvesting and utilizing woody biomass.

The final article, Chapter 4, is largely focused on examining Hypothesis 1.3, Hypothesis 2.1 and Hypothesis 2.2 through an in-depth analysis of knowledge levels by state and stakeholder group, and identifies questions, worries, and knowledge gaps and recommended outreach and communication methods to address these issues.

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Chapter 2: Stakeholder Opinions About a Woody Biomass To Biofuel Supply Chain in the Pacific Northwest

Submission Information

The article in this chapter will be submitted to *Biomass and Bioenergy*, a peer reviewed journal that focuses on environmental, management, and economic aspects of biomass resources and bioenergy.

Abstract

The Pacific Northwest has an advantage when it comes to producing liquid biofuels from woody biomass because of the large quantities of feedstock available in this region. When determining the practicality of a woody biomass to biofuel supply chain in the Pacific Northwest, it is also imperative to consider stakeholder support in addition to availability of natural resources. In 2013 a survey was conducted of vested interests in the Pacific Northwest to determine their opinions, worries, and support for various topic related to woody biomass harvest and biofuel production. Key themes in survey responses include statistically significant differences between support for various forms of feedstock by stakeholder groups. Most survey participants showed a high level of support for biomass activities in their region. Statistical analysis shows that environmental concerns and perceived benefits both affect the potential level of support for a wood based biofuel supply chain in this region.

Introduction

As knowledge and technology related to renewable energy increases, so does the demand. Many communities are evaluating the available natural resources in their regions for renewable energy developments, and in the Pacific Northwest woody biomass is plentiful. In this sense, Idaho, Montana, Washington, and Oregon are at an advantage when it comes to the emerging wood-based biofuels industry because wood and forestry resources are not evenly distributed across the United States, much less the world (Favero & Massetti, 2013; Obersteiner et al., 2006). This means that energy from woody biomass is not right for every location. When determining if it is a practical source for biofuels, there are certain social criteria which must be considered in addition to transport costs and feedstock availability (Martinkus et al., 2014; Monroe & Oxarart, 2011; Stidham & Simon-Brown, 2011). In the United States, the Pacific Northwest shows considerable potential for utilizing forest residuals

from harvesting and restoration treatments in addition to mill residues and construction waste (Obersteiner et al., 2006; Stidham & Simon-Brown, 2011; White, 2010).

In 2011, Washington State University was awarded a $40 million grant by the USDA to fund the Northwest Advanced Renewables Alliance (NARA), a project that aims to determine the economic, environmental, and social feasibility of starting a wood to aviation biofuel supply chain in the Pacific Northwest. NARA is a collaborative of private industries and educational institutions working to research, develop, and disseminate information about converting woody biomass to liquid aviation biofuels. The goal of the project is to identify a supply chain for aviation biofuels in the four state region of Washington, Oregon, Idaho, and Montana. Specifically, NARA is looking at utilizing currently unused byproducts of the lumber industries, construction and demolition waste, and both routine and fire-thinning forestry residues as feedstock for isobutanol production. The USDA selected the Pacific Northwest because of its abundant natural resources, and the amount of existing infrastructure that can be used in the harvesting and transportation of the raw materials for the production of isobutanol.

Significant time and resources have been devoted to developing models that evaluate scientific, environmental, and economical aspects of the wood to biofuels supply chain both by NARA and other research initiatives. However for a sustainable wood-based liquid biofuels industry to thrive in the Pacific Northwest, it is necessary to examine social aspects that will affect the industry, mainly stakeholder knowledge, opinions, and worries (Chin et al., 2013; Zoellner et al., 2008). Ultimately these stakeholders will be the ones employed in the industry, utilizing the fuel, and defining forest health for their region (Buchholz et al., 2007; Raffa et al., 2009). Despite the fact that the raw materials to make a woody biomass to aviation fuel supply chain are present in much of the Pacific Northwest, there are other factors which will affect the potential success of woody biomass as a source for fuel in this region such as community support, which is strongly influenced by the knowledge, opinions, and perceptions of its residents concerning woody biomass (Dale et al., 2013; Rosch & Kaltschmitt, 1999; Upreti, 2004).

Research has shown that in many cases the public is supportive of renewable energy (Heiskanen et al., 2008; Qu et al., 2011). Other studies have found that stakeholder opinions

about using woody biomass for biofuels vary based on stakeholder group and from community to community (Peelle, 2001; Selfa et al., 2011).

While the West in general has varying politics and geography, one common denominator in this region is the large expanses of federally owned land, and strong feelings relating to recreating in, utilizing, and managing the natural environment. The rural West has grown in the past 40 years, and the main reasons cited by those relocating from more urban areas are social environment, environmental quality and amenities, and recreation opportunities (Rudzitis, 1980). In addition, concern about environmental factors such as wildlife, fish, wilderness, and recreation has increased substantially since the 1960s (Steel et al., 1994). Because of the high value placed on physical environment, it is not surprising that newcomers and long time residents in the West also care a great deal about the management of federally owned land in their regions. Research indicates that residents of the Pacific Northwest have strong feelings about where and what type of timber harvests should take place and generally are against clear cutting of forests (Hansis, 1995; Ribe, 2006). Research also indicates people prefer protective or restorative management strategies over commodity based management strategies, both in the Pacific Northwest and in the nation as a whole (Rudzitis, 1980; Steel et al., 1994; Stidham & Simon-Brown, 2011).

With this information in mind, NARA researchers created a survey to assess the knowledge, opinions, and perceptions on various aspects of using woody biomass for biofuels production. The survey was administered to a variety of stakeholders in the Pacific Northwest and the findings show support and concerns of various levels across the region for using forest residuals and other wood waste as feedstock for a wood-based biofuels supply chain in the Pacific Northwest.

The objectives of this study are to 1) identify key themes in stakeholders' perspectives on using woody biomass for biofuels in the Pacific Northwest, 2) Identify differences and similarities in support by stakeholder group, state, and political affiliation, and 3) to determine what affect, if any, these opinions have on support for a woody biomass to biofuel supply chain in the Pacific Northwest. It is our goal to inform not only NARA of stakeholder worries and support, but other woody biomass to biofuel projects in the Pacific Northwest.

Methods

A mixed methods survey was developed to explore stakeholder knowledge, worries, and agreement with topics related to woody biomass feedstock sources, utilization, and biofuels production. Researchers designed the survey specifically to engage a targeted audience of individuals who are informed on various aspects of the wood to biofuels supply chain industry and who understand, to some extent, its impacts. The survey, consisting of 22 qualitative and quantitative questions, was emailed to vested interests in Oregon, Washington, Idaho, and Montana. It was sent to government officials at local, state, and federal levels; individuals working or involved in the wood products industry; tribal natural resource managers; and individuals with environmental conservation interests. Stakeholders were given the option to take the survey online, over the phone, or by mail.

The survey instrument was reviewed by multiple other USDA-NIFA Agricultural and Food Research Initiative grant researchers to ensure clarity and consistency, then piloted to ten stakeholders who were surveyed in person. Feedback from these ten respondents was used to refine the survey into the version that was distributed to the entire stakeholder list. In addition to Likert scaling questions, the survey provided opportunities for respondents to write specific questions they had about NARA, the wood to biojet conversion process, environmental related issues, and any other concerns they had.

To better understand stakeholders' opinions about biomass, multiple questions were asked about an attitude instead of one question. A single question, or indicator, is easier for data collection and data analysis, but it requires perfect measurement, which may not always be feasible. In order to increase reliability we chose several indicators for one construct. Multiple questions were asked about biofuel feedstocks, potential uses for biomass, worries, perceived benefits, and support of biomass/biofuel activities. These opinions and the questions can be seen in Table 3.

Table 3: Opinions were determined using multiple questions as indicators.

Opinion Constructs	Questions
Biofuel Feedstock	I agree/disagree that: • Woody biomass from timber harvesting should be used for bioenergy. • Woody biomass from forest thinning should be used for bioenergy. • Woody biomass from bug infested/diseased trees should be used for bioenergy. • Public forests should be managed for the production of forest products.
Woody Biomass Uses	I agree/disagree woody biomass should be used to supply: • A bioenergy power plant • A wood pellet production plant • A sawmill • A wood products manufacturer (i.e., furniture, interior paneling) • A liquid biofuels refinery
Worry	I am worried/not worried about: • The local economy of my region • Adverse environmental impacts related to woody biomass removal in the PNW • The current direction of forest management practices on public lands in the PNW • Rural Unemployment • Decreasing fossil fuel reserves • Adverse environmental impacts related to liquid biofuels production in the PNW • The ability to find renewable fuel sources • The current condition of forest health in the PNW • U.S. dependence on foreign oil
Perceived Benefits	I agree/disagree: • Increased use of liquid biofuels will off-set climate change. • The biofuels industry could improve the rural economy. • Using biofuels will reduce U.S. dependence on foreign oil. • The biofuels industry will have more benefits than risks for society. • The refineries in my region would provide employment opportunities. • Biofuels have a lower environmental impact than conventional (fossil) fuels.
Supply Chain Support	I support/oppose: • Obtaining woody biomass from public forests in my state • Siting a pre-processing depot facility in my county • Siting a conversion facility in my county • Siting a biofuels refinery in my county • Selling biofuels within the US that are derived from woody biomass

Overall 298 surveys were collected from 868 potential participants for a response rate of 34%. Researchers categorized participants into four broad groups: Industry, Conservation/Tribal, Local Interests, and Federal/State Government. Each stakeholder group is composed of sub-groups that were categorized based on similar answers to survey questions (Table 4). The participants who completed the survey included 99 individuals from the Industry group, 56

Conservation/Tribal stakeholders, 81 individuals from the Local Interest stakeholder group, and 62 individuals belonging to the State/Federal Government group.

Table 4: Stakeholder group subcategories.

Industry (n=99)	**Conservation/Tribal** (n=56)	**Local Interest** (n=81)	**Federal/State Gov.** (n=62)
Forest Industry	Tribal Members	University Extension	Academic Researchers
Non-Industrial Land Owners	ENGOs	Economic/Business Development	Extension Foresters
Private Foresters	Local Resource Managers	Interested Local Businesses/Investors	State Foresters
Industrial Landowners	Wilderness Outfitters/Recreation	City/Town Elected Officials	State and Federal Scientists
Harvesters/Haulers		County Elected Officials	State and Federal Natural Resource Managers
Secondary/Primary/Paper Products			District Rangers

Findings

Multiple themes have emerged from the analysis of this survey. Two themes that emerge from both the qualitative and quantitative survey results are environmental concerns and economic questions related to utilizing woody biomass for bioenergy and biofuels production. Support for a biofuel supply chain in the Pacific Northwest is potentially influenced by worries about adverse environmental impacts of biofuels, forest health, and economic feasibility. On the other hand, support could be positively impacted by perceived benefits of biofuels related to reduced wildfires and rural economic stability.

Environmental Worries

The majority of survey respondents, regardless of stakeholder category, indicated that they were worried about current forest health conditions in the Pacific Northwest and environmental impacts of woody biomass removal. Survey participants were asked to write in potential negative effects of removing biomass from forests, and the majority of the responses included environmental issues such as soil or water degradation, loss of material valuable to nutrient cycles, and loss of habitat. Participants were also asked to list possible benefits. These too had a strong environmental theme: healthier tree stands, reduction of fires, and less insect/disease damage (Laninga et al., 2015).

Environmental concerns were also apparent in quantitative portions of the survey where stakeholders were asked their level of worry about several topics. While environmental issues were worrisome to all stakeholder groups, Conservation/Tribal stakeholders were significantly more worried about adverse environmental impacts of liquid biofuels production and woody biomass removal (p=.000), and stakeholders from the Industry group were most worried about forest management practices on public lands in the Pacific Northwest (p=.006). Stakeholders from all groups indicated that they are worried about forest health in the Pacific Northwest (Figure 4).

When these same questions were looked at by political association of survey participants, participants that categorized themselves as moderately liberal to very liberal were significantly more worried (p=.000) about adverse environmental impacts of liquid biofuels production and removal than those who said they were moderately conservative to very conservative.

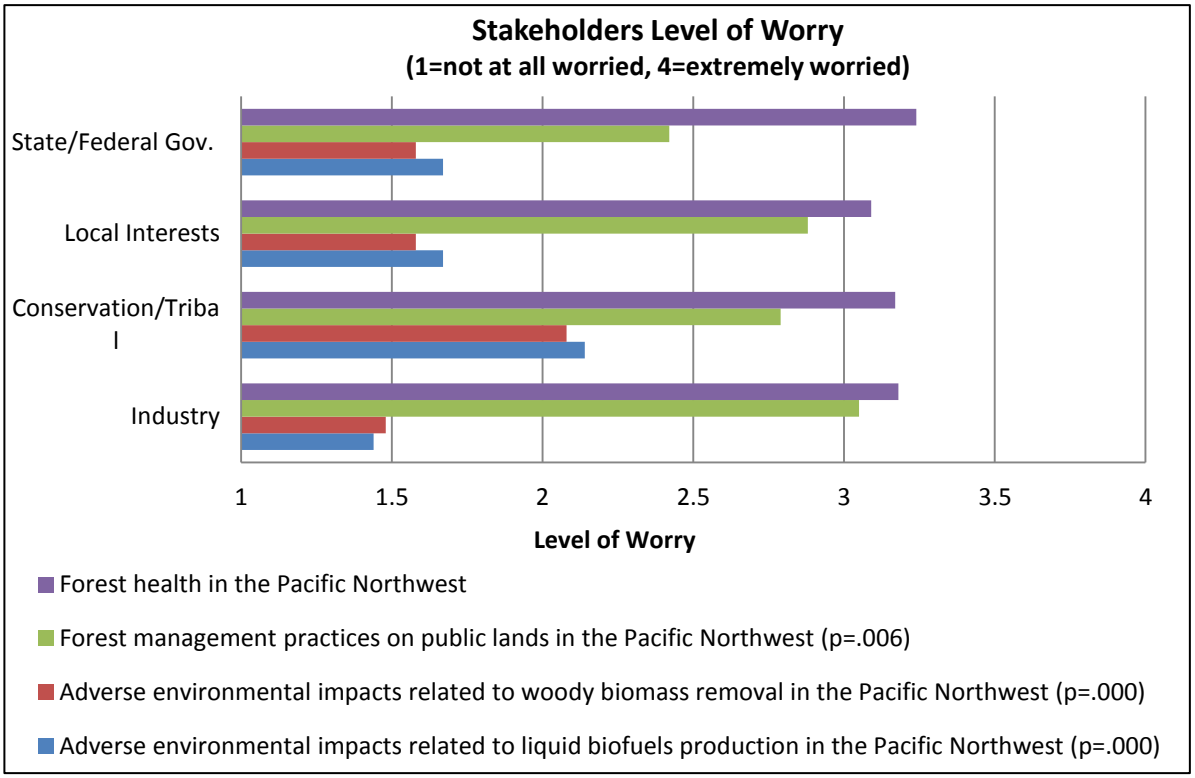


Figure 4: Level of worry by stakeholder group.

There were few significant differences between states' levels of worry with the exception of forest health in the Pacific Northwest. Stakeholders from Montana and Oregon showed significantly higher levels of worry than those from Washington and Idaho.

Economic Benefits and Worries

It is apparent that survey participants are concerned with economic issues and feasibility related to a wood based biofuels project. In the qualitative portion of the survey, many stakeholders wrote in questions such as "Will the raw materials have enough market value to make up for transportation costs?" and "Can it be economically competitive without government subsidies?" When asked what positive effects could come from removing woody biomass, 35% of Industry stakeholders said economic benefits as well as 23% of Conservation/Tribal stakeholders, and 30% of Local Interest and State/Federal Government stakeholders (Laninga et al., 2015).

The economic theme was also seen throughout quantitative portions of the survey results. The local economy and rural unemployment were listed among the top three concerns for almost every stakeholder group in every state (Moroney & Laninga, 2015). Stakeholders who identified as moderately conservative to very conservative were significantly ($p=.000$) more worried about these two topics compared to their liberal to very liberal counterparts. When asked their level of agreement on a scale of 1 to 5 where 1 was "strongly disagree" and 5 was "strongly agree," all stakeholders showed high levels of agreement with the statements "The biofuel industry could improve the rural economy" and "The refineries in my region would provide employment opportunities."

Perception Differences Between Stakeholder Groups

Perceptions on biofuel feedstock and conversion facilities were compared among the four different stakeholder groups (Industry, Conservation/Tribal, Local Interests, and State/Federal Government) using MANOVA with univariate analysis (Table 3&4) and post-hoc Tukey comparison (Figure 3). The analysis results show that perceptions of stakeholders do not differ regarding the use of logging residues, routine thinning, and diseased trees as feedstock for the production of biofuels. Opinions about these sources of feedstock were all relatively positive with averages of agreement ranging from 3.75 to 4.45 on a scale of 1 to 5 where 1 was strongly disagree and 5 was strongly agree. However, Conservation/Tribal have

significantly lower levels of agreement that "public forests should be managed for production of forest products" than the other stakeholder groups (Table 5).

Table 5: Stakeholder perceptions on *sources* of woody biomass.

Perception	**P-Value**
Agree use of logging residues from timber harvest	.198
Agree use of thinning residues	.261
Agree use of bug infested/diseased trees	.102
Agree public forests should be managed for production of forest products	**.001**

*bold p-value is less than .05

Conservation/Tribal stakeholders also hold significantly different opinions regarding uses of the feedstock with Tukey mean comparison p-values smaller than 0.05 (Table 4). Specifically, Conservation/Tribal stakeholders have lower levels of agreement for using woody biomass to supply a power plant, a wood pellet production plant, a saw mill, value added products, or a liquid biofuels refinery compared to the other stakeholder groups as shown in Figure 5.

Table 6: Stakeholder perceptions on *uses* of woody biomass.

Perception	**P-Value**
Agree use for power plant	**.001**
Agree use for pellet	**.009**
Agree use for saw mill	**.000**
Agree use for value added	**.004**
Agree use for liquid refinery	**.019**

*bold p-value is less than .05

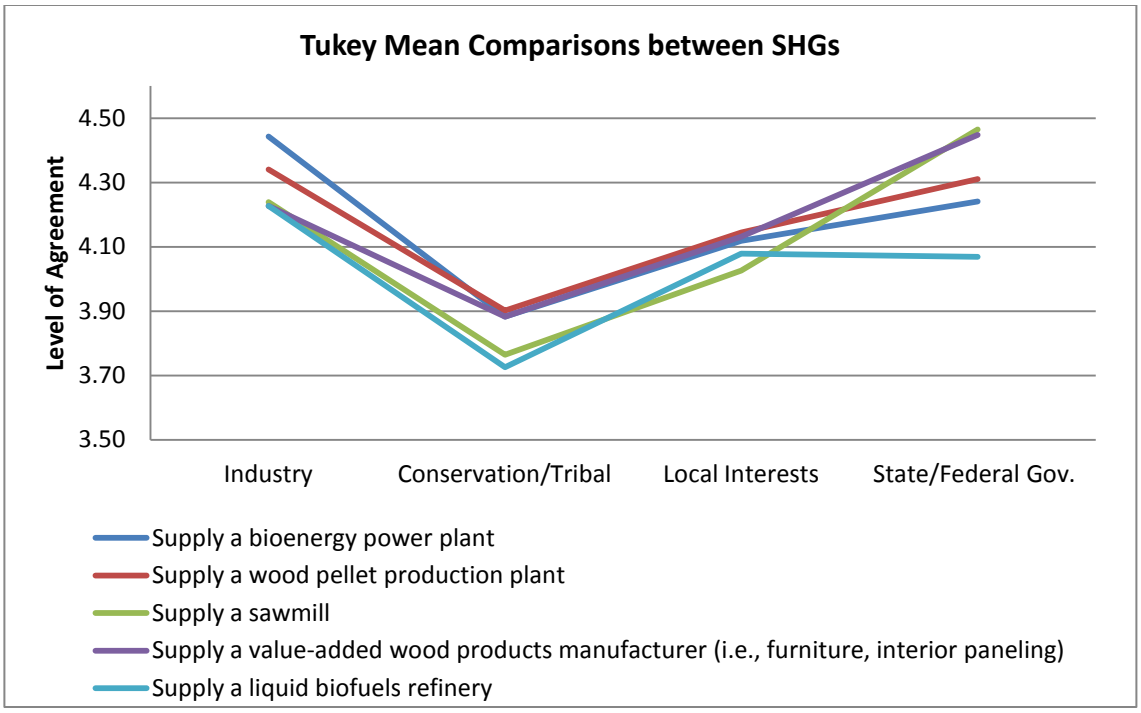


Figure 5: Mean comparisons between stakeholder groups on sources and uses of Biomass. Agreement was measured on a scale of 1-5 where 1 was "strongly disagree" and 5 was "strongly agree."

Impact of Concerns and Benefits on Supply Chain Support

Statistical analysis was performed to determine how the identified constructs were affecting stakeholders' support for biofuels activities in their region.

Cronbach's alpha was used to measure the internal consistency of each of our constructs: worries, perceived benefits, and support. In this study nine items were used to measure stakeholders' level of worry regarding bioenergy related topics, six items to measure perceived benefits of biofuels, and five items to measure stakeholders' support for biofuel related activities within their region. Cronbach's alpha was used to determine if each question indicator in the construct measured the same thing (worries, perceived benefits, and support) (Table 7).

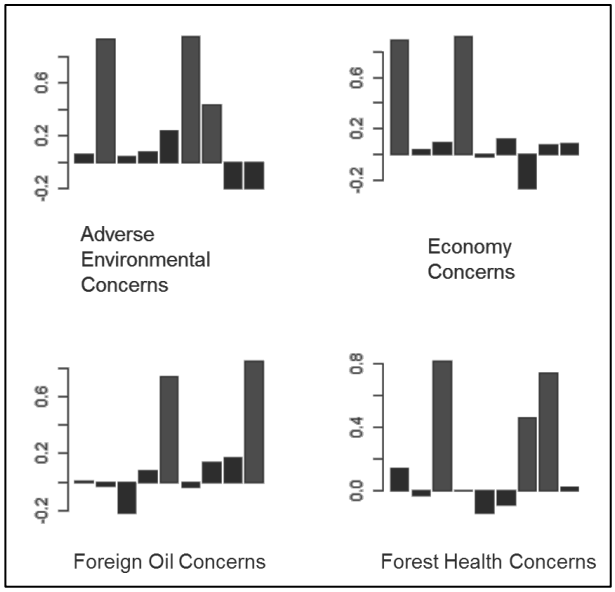
Table 7: Cronbach's alpha and reliability of measured constructs.

	Worries	Perceived Benefit	Support
Cronbach's alpha	0.6343	0.7817	0.9384

When Cronbach's alpha is larger than 0.9, the items' internal consistency is excellent, when Cronbach's alpha is between 0.7 and 0.9 the items' internal consistency is good, and when Cronbach's alpha is between 0.6 and 0.7, the items' internal consistency is acceptable, and the items' internal consistency is poor or unacceptable if Cronbach's alpha is below 0.6 (Cortina, 1993). Table 5 shows that the item internal reliability of "support" is excellent, and item internal reliability of "perceived benefits" is good, whereas the item internal reliability of "worries" is acceptable. Based on this, the mean values of questions measuring perceived benefits and support were used to simplify analysis.

Instead of using the value of nine measured items of worries, principle factor analysis with a Promax rotation was performed to determine the latent structure of the questions measuring worry to determine if different concerns were being measured. The scree plot indicated three or four factors should be maintained, and the explained variance plot showed four or five factors should be maintained in order to account for approximately 80% of the total variance. Three, four and five factors were tested, but only four principal factors were meaningful and interpretable (Figure 6). The first principal factor, "Adverse Environmental Concerns," is strongly correlated with environmental impacts related to wood biomass removal and adverse environmental impact related to liquid biofuels, and somewhat related with forest management on private lands. The second principal factor, "Economy Concerns," is strongly correlated with the local economy and rural unemployment. The third principal factor, "Foreign Oil Concern," is strongly correlated with decreasing fossil fuels and U.S. dependence on foreign oil. The fourth principal factor, "Forest Health Concerns," is strongly correlated with forest management practices on public lands and forest health, and somewhat related to forest management on private lands.

After standardizing the variables, we regressed support on concerns (four principal factors) and benefits. The combined residual plot is shown in Figure 7.

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Loadings:
      [,1]   [,2]   [,3]   [,4]
 [1,]         0.890         -0.141
 [2,] -0.935
 [3,]                 0.221 -0.819
 [4,]         0.918
 [5,] -0.238         -0.740  0.143
 [6,] -0.952  0.121
 [7,] -0.435 -0.265 -0.135 -0.462
 [8,]  0.198         -0.170 -0.743
 [9,]  0.202         -0.849

                [,1]  [,2]  [,3]  [,4]
SS loadings    2.117 1.744 1.373 1.486
Proportion Var 0.235 0.194 0.153 0.165
Cumulative Var 0.235 0.429 0.582 0.747
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Figure 6: Four principal factors for concern and loadings.

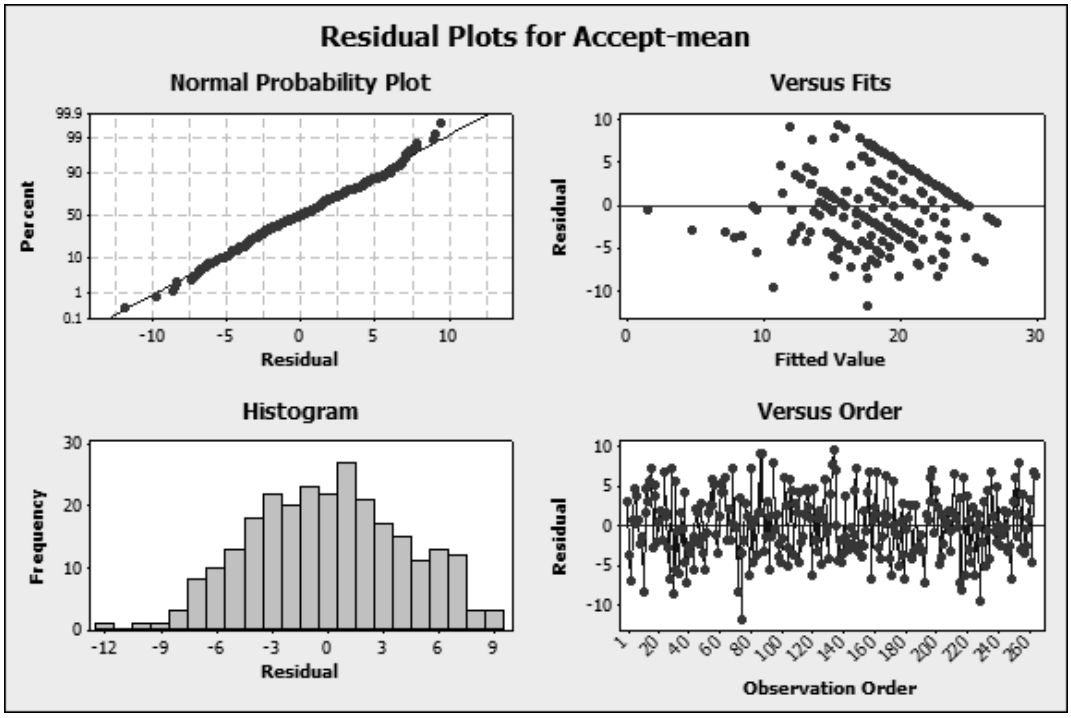

Figure 7: Residual plots

Approximately 50% of the total variance in support is explained by the model (Table 8). Additionally, we found that "Adverse Environmental Concerns", "Forest Health Concerns" and perceived benefits are significant predictors of support of biofuel activities in stakeholders' regional areas (Table 8). Among the three significant predictors, perceived benefits is the most important predictor with standardized coefficient of 0.57 (p-value=0.000). Support is positively related with perceived benefits, indicating that the higher level of agreement with perceived benefits of using biofuels, the more accepting a stakeholder is of biofuel activities in her/his region.

Table 8: Regression support on standardized concerns and benefits.

Term	Coef	T	P-value
Adverse Environmental Concerns	0.223	4.362	**0.000**
Economy Concerns	-0.0475	0.048	0.320
Foreign Oil Concerns	-0.08	-1.67	0.097
Forest Health Concerns	-0.113	-2.42	**0.016**
Perceived Benefits	0.57	11.68	**0.000**
S = 0.711, R-sq =50.38%; R-Sq(adj) = 49.42%			

Support is also positively related to the "Adverse Environmental Concerns" with standardized coefficient of 0.223 and p-value of 0.000. When collecting the original data, we used a 4-point likert scale, where 1= not at all worried and 4=extremely worried. Therefore, based on the regression model, the less stakeholders are worried about adverse environmental impact of biofuels, the greater the possibility of stakeholders support for biofuel activities in their region. However, support is negatively related with the "Forest Health Concerns" with standardized coefficient of -0.113 and p-value of 0.016. The more stakeholders worry about forest health, the greater the possibility stakeholders will accept biofuel activities in their region due to the belief that forests need some regular management in order to maintain health.

Discussion and Conclusion

Woody biomass is an abundant resource in the Pacific Northwest and shows great potential as a feedstock for liquid biofuels, but stakeholder opinions and lack of support can be an

obstacle (Evans, 2008; Martinkus et al., 2014; Stidham & Simon-Brown, 2011). This study shows important information on stakeholder perspectives on a variety of topics related to a potential wood to biofuel supply chain in the Pacific Northwest. While there are statistically significant differences in stakeholder views on some items, overall our survey results indicate a high level of support for using various sources of woody biomass, for utilizing woody biomass in different biomass operations, and for producing liquid biofuels in the region.

One of the main themes identified through quantitative and qualitative analysis is stakeholders' concerns about adverse environmental impacts of biofuel harvest and production, and concern about forest health in the Pacific Northwest. Other studies have found similar results (Evans, 2008; Monroe & Oxarart, 2011; Stidham & Simon-Brown, 2011). The concerns stakeholders listed included soil degradation, loss of wildlife habitat, and issues with nutrient cycles as a result of overharvesting biomass. Conservation/Tribal stakeholders have significantly different perceptions about what applications woody biomass should be used for when compared to stakeholders in Industry, Local Interest, and State/Federal Government groups. They showed lower agreement for managing public forests for forest products as well as less agreement for using woody biomass to supply bioenergy power plant, wood pellet production plant, sawmill, wood products manufacturing, or liquid biofuels refinery than the other three stakeholder groups.

Factor analysis showed stakeholders are also worried about their local economies as well as rural unemployment. Many stakeholders, responding to open-ended questions about economics, wrote about the cost of harvesting and transporting materials and were concerned that the fuel would not be economically competitive with traditional fossil fuels without government subsidies. Additionally, regression analysis shows that support of biofuel related operations is negatively impacted by the concerns about adverse environmental impacts of biofuel production and concerns about forest health. It is positively impacted by perceived benefits of biofuels, which include improvement of the rural economy, employment opportunities, environmental benefits, and reduced dependence on foreign oil.

Results from this study are intended to inform NARA team members of the worries and opinions regarding a Pacific Northwest woody biomass to liquid biofuel supply chain in order to aid them in outreach, the production of communication materials, and assess possible social

obstacles related to public support. However, it has broader application as well, and can be used by the federal, state, tribal and local governments that are examining the feasibility of wood-based bioenergy and biofuels production in the Pacific Northwest.

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Chapter 3 Wood to Wing: Stakeholder Perspectives on a Wood-based Biofuels Industry in the Northwest United States

Submission Information

This article will be submitted to the *Journal of Environmental Policy & Planning.* This peer reviewed journal publishes articles that do critical analysis of environmental policy issues and issues which affect planning on many levels such as social, political, economic, geographical, legal, and cultural.

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Abstract

With mounting scientific evidence confirming anthropogenic impacts on global climate change, the drive to develop renewable energy sources in order to reduce CO2 emissions is growing. The Northwest Advanced Renewables Alliance (NARA) is a regional public/private consortium in the northwestern U.S. examining the feasibility of a wood-based liquid biofuels industry. Significant resources have been devoted to investigating the environmental and economic viability of the wood to biofuels supply chain. However, there has been limited research assessing the knowledge, opinions, and perceptions of stakeholders about using woody biomass as a source for biofuels. To address these gaps, we conducted a survey with vested interests in the Northwest. Our findings show that respondents were concerned about forest conditions, especially current excess fuel loads; thought that the regional economy would benefit from collecting forest residuals and that removing woody biomass would produce healthier tree stands; and were worried about the negative impacts of a wood-based biofuels industry related to soil degradation, loss of organic material, and loss of wildlife habitat.

Introduction

Scientists are beginning to shed light on the current and future impacts of climate change in different regions of the United States and around the world, while the demand for renewable energy is growing in both the private and public sectors. It is imperative to understand stakeholder perspectives about using natural resources available in their communities that can be used as feedstocks for various renewable fuels. Regional initiatives across the United States are investigating a variety of potential feedstocks for renewable fuels and examining what role communities and their regions can play in renewable fuel supply chains. Several initiatives in the northwestern United States are looking at the feasibility of using forest residuals, abundantly available in Oregon, Washington, Idaho, and Montana, as a feedstock for liquid biofuels. While many studies have focused on the environmental aspects as well as the economic impacts of using these natural resources, it is also important to examine stakeholders' social acceptability, concerns, and perceived benefits of using these natural resources. Such an examination is important to better understand what roles communities see themselves playing, and what concerns they have about participating in this emerging industry. While this study is heavily rooted in social science, the surveying process along with the potential benefits and concerns identified by stakeholders span various topics important to planning and community development professionals, including the environment, economy, and infrastructure of communities in the northwestern United States.

Mounting scientific evidence shows that the effects of a warming climate are apparent across species and ecosystems on every continent worldwide (U.S. Global Change Research Program, 2009). Recent global surface temperatures are some of the highest recorded since 1850 (Intergovernmental Panel on Climate Change, 2013; Malmsheimer et al., 2008). This increase in temperature is associated with increasing concentrations of heat-trapping greenhouse gases (GHGs), the most significant being carbon dioxide (CO2), which is the main offender in temperature rise over the last fifty years (Intergovernmental Panel on Climate Change, 2013; Malmsheimer et al., 2008; U.S. Global Change Research Program, 2009). Multiple scientific models concur that this change is largely influenced by human activity, such as fossil fuel use and deforestation, and that the rapidly rising temperature trend will not be slowing anytime soon, especially without modification of human actions

(Intergovernmental Panel on Climate Change, 2013; Hannah, 2011). In light of these discoveries, research has turned to developing technologies to mitigate global warming by replacing fossil fuel use with biofuels in order to reduce CO2 emissions. One source of biofuel showing great potential for practical use is woody biomass from forest residues, which can be used for a variety of energy applications including aviation biojet fuel.

Although bioenergy from forest residuals is a possible substitute for fossil fuels, there are potential limitations to utilizing this feedstock for fuel. For example, forest resources are not evenly distributed across the United States, much less the world (Favero & Massetti, 2013; Obersteiner et al., 2006). This means energy from woody biomass is not right for every location. When determining if it is a feasible solution, the supply and cost of transport as well as the source of the feedstock must be considered to determine if woody biomass is a good fit (Olszowy , 2011). In the United States, the Northwest shows considerable potential for utilizing forest residuals from harvesting and restoration treatments, in addition to mill residues and construction and demolition (C&D) waste (White, 2010; Obersteiner et al., 2006).

Forests have been studied and managed for quite some time, and it is known that forests are a critical component to the carbon cycle (Malmsheimer et al., 2008; Nabuurs et al., 2007). Because forests cover nearly thirty percent of the land area on the earth, they are a large terrestrial source of carbon sequestration (Nabuurs et al., 2007). When used for energy, woody biomass is considered by some to be carbon neutral, because the carbon that is a product of its energy expenditure is absorbed at relatively the same rate by the vegetation that is grown in its place (Olszowy , 2011). However, this is debatable, especially when the fuel used to harvest, transport, and process the biomass is taken into account. Woody biomass also has the additional benefits of being local and easily stored in many places in the form of chips, pellets, or liquid fuel. The sources of woody biomass that can be used to produce biofuels include: logging residues, forest treatments to reduce fuel buildup in fire-prone forests, sawdust, wood chips, pellets, bark, forest products industry wastes, and urban wood residues (Olszowy, 2011). Often times, these residues and waste products are left unused and are either burned or left to decay in the forest. These practices lead to more CO2 entering into the atmosphere (Malmsheimer et al., 2008).

The reduction of surplus fuels can diminish the severity of wildfires, which contribute to GHGs. By preventing burning, or catastrophic burning, the release of CO2 from wood is also prevented (Malmsheimer et al., 2008). The thinning of small diameter trees also removes excess fuel and lessens the competition between individual trees for nutrients and water. When done correctly, this can produce healthier trees which can be more resilient to drought and insect infestations. Much of the fuel from these types of harvest is also left to decay on the forest floor, contributing to release of carbon into the atmosphere. However, with new technology this waste wood could be used to produce bioenergy.

Significant time and resources have been devoted to developing models that evaluate scientific, environmental, and economical aspects of the wood-to-liquid biofuels supply chain (NARA 2014). The Northwest Advanced Renewables Alliance (NARA), a collaboration between universities, government, and industry and supported by a $40 million US Department of Agriculture grant awarded to Washington State University in 2011, is one such initiative. NARA is examining the feasibility of producing liquid biofuels and bio-based products from forest residuals and C&D waste in Oregon, Washington, Idaho, and Montana. However, for a sustainable wood-based liquid biofuels industry to thrive in the Northwest, it is necessary to examine its social acceptability. In particular it is important to ask key questions about stakeholder perceptions, knowledge, and potential acceptance or rejection of this industry on a local, state, and regional level (Chin et al., 2013; Zoellner et al., 2008). Ultimately these stakeholders will be the ones impacted by its production, employed in the industry, utilizing the fuel, and defining forest health for their region (Buchholz et al., 2007; Raffa et al., 2009). Despite the fact that the raw materials to make a wood-based liquid biofuels supply chain are present in much of the Northwest, there are other factors that will affect the potential success of woody biomass as a source for fuel in this region. One of these factors is community support, which is strongly influenced by the knowledge, opinions, and perceptions of its residents concerning woody biomass (Dale et al., 2013; Rosch & Kaltschmitt, 1999; Upreti, 2004). It is also important to recognize that different groups of stakeholders might have different goals when it comes to using woody biomass for biofuels (Johnson et al., 2013).

To date there has only been limited research assessing the knowledge, opinions, and perceptions of stakeholders about using woody biomass as a source for liquid biofuels, how they vary by region and stakeholder group, and what affect these factors have on the social acceptability of a wood-based biofuels supply chain. This is an important area of study because lack of support and public perception have been cited as the main obstacles which can hinder the success of siting bioenergy and biofuels production facilities (Rosch & Kaltschmitt, 1999; Upham, 2009a; Walker, 1995). Studies indicate that opinions regarding the use of woody biomass will vary between those growing or harvesting the feedstock and environmentalists (Peelle, 2001). It has also been hypothesized that different stakeholders will have varying concerns and perceive different benefits from utilizing woody biomass (Benjamin et al., 2009; Peelle, 2001).

In order to address these gaps in the literature, we conducted a survey to evaluate a variety of stakeholders in the Northwest to determine their knowledge, opinions, and perceptions on various aspects of using woody biomass for biofuels production. From this survey we identified stakeholder support and concerns to examine regional levels of support for using forest residuals and other wood waste for a wood-based biofuels supply chain in the Northwest. This paper's focus is to examine respondents' support for utilizing woody biomass for biofuels production, their perceived conditions of the forests they are most familiar with, and the benefits and concerns they associated with a wood-based biofuels industry.

Theoretical Framework

In order to gather information about the social and cultural structures that exist within the research area, communicative planning theory was heavily relied on because it casts local stakeholders in the role of experts about their own region, lifestyle, and values. This theory is two-fold: first it emphasizes two-way communication between planners and stakeholders, and second it recognizes that there are multiple ways of knowing, valuing, and giving meaning. The second aspect of communicative planning influenced the design of this study. The theory also emphasizes the importance of a dynamic research process that can be adjusted as stakeholder input is received. This theory is highly applicable when policy or industrial decisions must be made at a community level.

In many areas, people have an in-depth understanding of the issues that their community faces because of their deep roots in the area. Communicative planning recognizes a range of ways of knowing, valuing, and giving meaning; and understands that this range will vary by location. Healy's (2003) approach takes into account the spatial demographics of acceptance by acknowledging that there are existing politics and norms in communities, which vary by region. Having multiple stakeholders involved in a surveying process attempts to paint a clearer picture of the specific needs and influences in a community (Healey, 2003). This is a crucial component when identifying any spatial trends involving knowledge, attitudes, and opinions.

Communicative planning looks at what is valued about a local environment, how these values might be threatened, what specific projects might be successful given community dynamics and values, and who will benefit (Healey, 2003). Subscribing to a theory that emphasizes understanding the underlying social structure and attitudes of an area focuses this research on stakeholder input.

When research questions and hypotheses were being formulated for this study, the underlying concepts of communicative planning, especially the idea that values and norms vary regionally, by community, and by stakeholder group, were considered. With this in mind, questions that considered specific differences in attitudes and opinions demographically, between stakeholder groups, and by region were generated.

Methods

A mixed methods survey was developed to explore a variety of topics related to woody biomass feedstock collection, utilization and biofuels production. The survey, consisting of 22 qualitative and quantitative questions, was emailed to vested interests in Oregon, Washington, Idaho, and Montana. Researchers designed the survey specifically to engage a targeted audience of individuals who would be informed on various aspects of the wood to biofuels supply chain and industry and would understand, to some extent, the impacts of the industry. With this is mind, the survey was sent to government officials working at the local, state, and federal levels; individuals working or involved in the wood products industry; tribal

communities, and individuals with environmental conservation interests. Stakeholders were given the option to take the survey online, over the phone, or by mail. Initial email invitations were followed by a reminder email one week later, then a phone call two weeks out, and finally a hard copy in the mail, a month to six weeks after the initial email invitation.

To ensure that every participant was interpreting each question in the same way and able to respond accurately, the survey instrument was reviewed by multiple USDA-NIFA Agricultural and Food Research Initiative grant researchers and then piloted with ten vested interests who were surveyed in person. Feedback from these ten respondents helped refine the survey into the version that was distributed to the entire stakeholder list.

Surveys were sent to 868 stakeholders in Oregon, Washington, Idaho, and Montana; 298 participated, resulting in a 34% response rate. Researchers categorized participants into four broad groups, which were determined by stakeholder occupation as well their responses to survey questions. The four categories were Industry, Conservation/Tribal, Local Interests, and Federal/State government. Researchers also categorized survey respondents by state and region, defined by geographic similarities. The three regions were: Cascade to Pacific (C2P) (including western Washington and Oregon), Western Montana Corridor (WMC) (including western Montana, northern Idaho and northeastern Washington), and Columbia Plateau (CP) (including eastern Washington and Oregon and southern Idaho) (Figure 8).

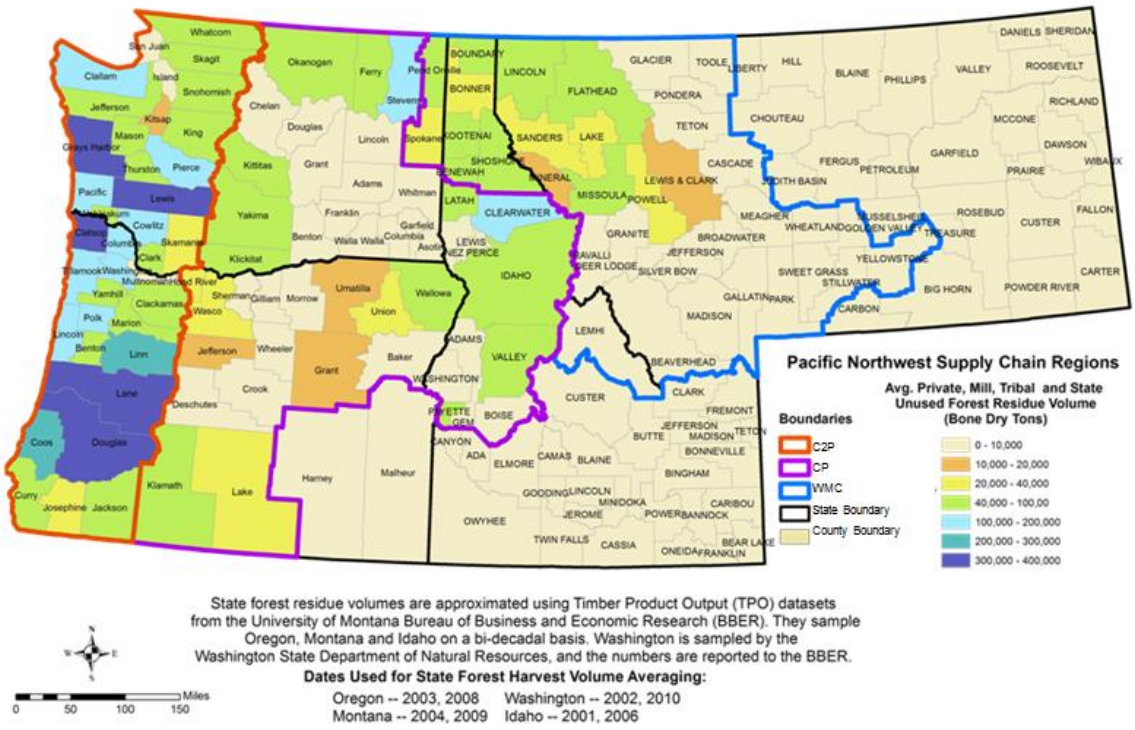

Figure 8: Four-state NARA map with regions delineated.

In addition to Likert type scaling questions, the survey provided an opportunity for respondents to write personal opinions in response to seven open-ended questions. This paper shows stakeholder responses to one quantitative question about level of support for woody biomass utilization and three of the open-ended questions, which asked about forest health, benefits of removing woody biomass from forests, and the negative consequences which could result from utilizing woody biomass for biofuels.

Responses to the open-ended questions were analyzed through content analysis of participant responses to the open-ended survey questions. First, a master list of codes was developed for each open-ended question from the initial reading of a sample of responses. A second researcher independently developed their own list for the same questions, and the two lists were compared and revised in order to ensure consistency of categories (Hruschka et al., 2004). The final list was used to categorize responses ensuring that themes were broken down into unambiguous categories, which could be tallied (The University of Reading Statistical Services Centre, 2001). Next, three coders used these categories to code each participant's

response for their perceived benefits, perceived negatives, and their answers about forest conditions. Using Krippendorff's Alpha, an average inter-coder reliability of .90 was achieved for perceived benefits, .76 for perceived negatives, and .81 for forest conditions between the three researchers.

Table 9 shows the response rates of survey participants by region, state, and stakeholder group. Responses were examined by these categories to examine potential geographic and social differences.

Table 9: Survey Respondent Profile

Category	N	%
Region		
WMC	94	28%
MC2P	113	33%
CP	133	39%
State		
Idaho	86	28%
Washington	85	29%
Oregon	70	24%
Montana	57	19%
Stakeholder Group		
Industry	99	33%
Conservation/Tribal	56	19%
Local Interests	81	27%
State/Federal Gov't	62	21%

Findings

In this section, we describe the responses to one quantitative questions showing level of support for woody biomass utilization and three open-ended questions related to forest conditions/forest health, the benefits of using woody biomass for biofuels production, and potential negative consequences associated with removing woody biomass for biofuels production.

Support for Biomass Utilization

Before discussing details of the open-ended question responses, we wanted to set the stage with the results from one of our quantitative questions. The question asked for respondents' level of agreement (e.g., strongly disagree to strongly agree) on the following statements: *Woody biomass should be used to supply*: a) *a bioenergy plant, b) a liquid biofuels refinery,* or c) *woody biomass should not be removed from the forest, regardless of its potential use*.

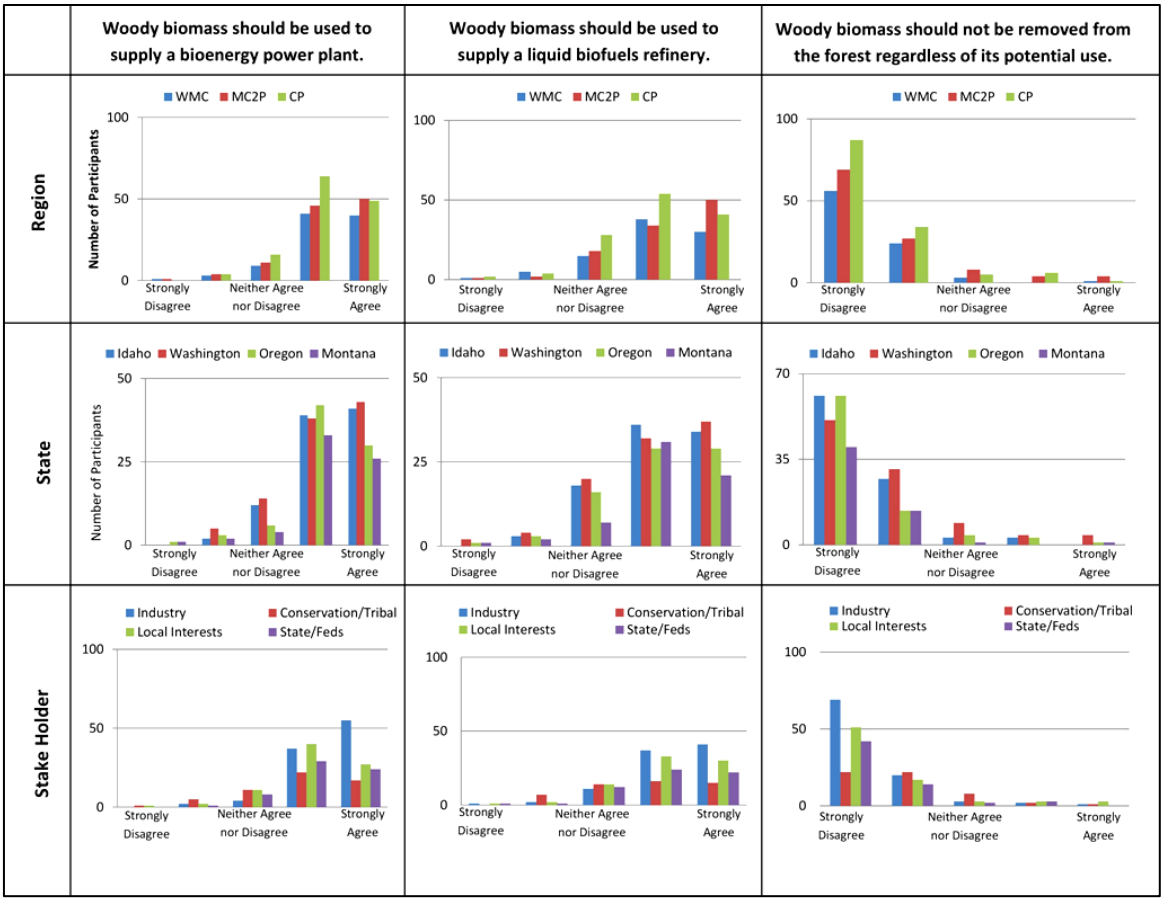

Figure 9: Participants' level of agreement with three statements about woody biomass use by region, state, and stakeholder group.

Figure 9 shows the results of these questions by region, state, and stakeholder group. It is apparent that regardless of region, state, or stakeholder group, the majority of respondents agree that woody biomass should be used to supply a bioenergy power plant or liquid refinery, and disagree with the statement that woody biomass should *not* be removed from the forest, regardless of its potential use. Forest Health

Stakeholders were asked to respond to an open-ended question regarding forest conditions/forest health. After a respondent listed the forests that they were most familiar with (e.g., public vs. private), the following question was posed: *How would you describe the current forest conditions in the forests you listed?* Stakeholder responses varied. A participant answered: "A mix of healthy and troubled forests. There are some pine beetles and other pest problems, and lack of proper thinning and maintenance in a lot of areas." Since some

respondents were familiar with more than one forest, responses may have touched upon radically different perspectives. One respondent wrote: "Major forest health issues on public lands- insects, disease, and high wildfire potential. Forest health is much better on the private lands that are more intensively managed." Responses, such as these, were reported in all the answer categories that were applicable. For example, the information included in the second quoted response would have been coded as being familiar with both (public and private). Then, within that category, insects, diseases, and fire hazard would have been reported. Additionally, the 'healthy' response would be included for that same person. Generally speaking, privately held forests were reported to be healthier than public forests. Healthy forests, as described by stakeholders in this survey, are well managed lands that have sustainable practices in place. Examples of stakeholder respondents whose comments reported unhealthy forests wrote "*major forest health issues*," *"underutilized," "needs to be salvaged," "abysmal with little management"* and *"failing to meet public expectations."* Table 10 shows that over half (54%) of respondents familiar with private forests considered these forests healthy. Additional findings show that stakeholders who responded only about privately held forests were less concerned about diseases and excess fuel loads than stakeholders who responded specifically about public lands. Twelve percent of respondents who reported either on public or private forests, or who reported familiarity with both, listed insects as a forest health issue.

Table 10: Forest health by forest type.

Forest Type	N	Healthy	Diseased	Excess Fuel	Fire Hazard	Declining Health	Insect Problems
Private	26	54%	0%	15%	16%	8%	12%
Public	170	21%	8%	34%	29%	24%	12%
Both	96	40%	14%	25%	24%	33%	12%

In addition to separating forest health responses by forest type, responses were categorized by state. Representatives from Idaho and Oregon reported the most concern about forest conditions. In particular, about a third (32%) of respondents from these two states were concerned about diseases in their forests (Table 11). Twenty four percent of stakeholders from Montana had concerns about diseases, while only eleven percent of responses from Washington stakeholders brought up this issue. About a quarter (24%) of respondents from

Montana also discussed insect problems when discussing forest conditions. This is in contrast to twelve percent of Washington respondents, nine percent of Oregon respondents and five percent of those from Idaho. Surprisingly, a similar percentage of respondents from each state reported healthy forest conditions: Idaho 27%, Montana 32%, Oregon 28%, Washington 30%.

Table 11: Forest health by state.

State	N	Healthy	Diseased	Excess Fuel	Fire Hazard	Declining Health	Insect Problems
Idaho	85	27%	32%	24%	28%	7%	5%
Montana	50	32%	24%	14%	28%	8%	24%
Oregon	71	28%	32%	39%	21%	1%	9%
Washington	82	31%	11%	28%	23%	4%	12%

In order to accurately assess the likelihood of biofuel industry success, NARA works at regional scales, which are determined by functional boundaries rather than state boundaries. Oregon, Washington, Idaho and Montana borders are strategically reconfigured into three regions based on biogeophysical assets: the Cascade to Pacific (C2P), the Western Montana Corridor (WMC)**,** and the Columbia Plateau (CP). For the most part, there were many similarities between state-based and regional-level responses. Major concerns mentioned by respondents were fire hazards and insect problems. When responses related to public and private forests were combined, healthy forests were reported at about the same frequency as unhealthy forests (Table 12).

Table 12: Forest health by region.

Region	N	Healthy	Diseased	Excess Fuel	Fire Hazard	Declining Health	Insect Problems
CP	99	35%	11%	31%	21%	35%	19%
WMC	80	36%	6%	13%	18%	31%	29%
C2P	87	44%	10%	27%	20%	36%	11%

Survey respondents were also categorized by stakeholder group. Participants were identified as belonging to one of 39 different stakeholder groups; these 39 groups were condensed into four broad categories using the similarities in answers to survey questions as well as the their professional background. The four categories are Industry Professionals, Conservation/Tribal, Local Interests, and State/Federal Government. Respondents included in the Industry category

included private foresters, non-industrial land owners, primary and secondary products producers, harvesters and haulers, and individuals who were involved on any level of the forestry industry. Participants categorized as Conservation/Tribal stakeholder group include members of ENGOs, local resource managers, recreation and wilderness outfitters, and forest or natural resource managers from tribal communities. The Local Interest stakeholder group included anyone who operates mainly on a city or county level. These people include university extension, economic and business development professionals, elected officials, and interested local business investors. Stakeholders categorized into the State/Federal Government group included public foresters, academic researchers, state or federally employed biologists, as well as federal district rangers. Almost half (44%) of industry professionals indicated that the forests they were most familiar with were healthy, in contrast to less than a quarter (17-18%) of participants from all other stakeholder groups. Stakeholders at the Federal/State level were more concerned about disease in forests than any other stakeholder group. While the Federal/State stakeholders' answers most frequently included comments about excess fuel in forests, all four groups felt that there was an excessive amount of material in the forests with which they were most familiar. The conditions that Conservation/Tribal stakeholders identified most frequently included excess fuel and fire hazards as well as insects and general unhealthy forest conditions (Table 13).

Table 13: Forest health by stakeholder group.

SHG	n	Healthy	Diseases	Excess Fuel	Fire Hazard	Unhealthy	Insect Problems
Industry	91	44%	8%	21%	14%	36%	22%
Conservation/Tribal	50	18%	4%	24%	24%	32%	24%
Local Interests	78	18%	9%	31%	31%	24%	19%
Federal/State	71	17%	13%	42%	28%	35%	18%

Positive and Negative Effects of Removing Woody Biomass

The survey asked two questions regarding the possible effects of removing woody biomass from forests. The two questions were: 1) *What are the positive effects, if any, of removing woody biomass?* and 2) *What are the negative effects, if any, of removing woody biomass?* For these questions, we examine the responses by region and stakeholder category.

Positive Effects

The three most mentioned positive effects of removing woody biomass were: creating an economic stimulator, decreasing the chance of catastrophic fires, and increasing the overall health of forests. Table 14 shows the responses categorized by region. One third (33%) of regional stakeholder respondents felt that there would be positive economic outcomes as a result of removing woody biomass from forests. While two thirds (66%) of those stakeholders wrote that the chance of catastrophic fires would decrease as a result of removing woody biomass, more respondents from the CP and WMC regions mentioned this than those from the C2P. An average of forty three percent of respondents thought that there would be healthier tree stands as a result of removing woody biomass from forests.

Table 14: Positive effects by region.

Region	N	Economy	Fire	Healthier Tree Stands	Insect	Renewable Energy
CP	103	34%	69%	44%	10%	20%
WMC	79	30%	70%	43%	8%	22%
C2P	88	34%	59%	43%	8%	16%
Average	270	33%	66%	43%	9%	19%

We also looked at benefits broken down by stakeholder category (Table 15). While the averages across the themes are similar to those by region, it is noteworthy that respondents in the Industry group considered the benefits to the economy, decreased insect problems and opportunities for renewable energy more often than the other stakeholder groups. Almost three quarters of respondents in the Local Interests and State/Federal stakeholder groups saw reduced fires as a benefit. This was the most frequently identified benefit in the Conservation/Tribal and Industry groups as well.

Table 15: Positive effects by stakeholder group.

SHG	n	Economic Benefits	Reduce Fires	Healthier Tree Stands	Decrease Insect Damage	Renewable Energy
Industry	81	35%	67%	38%	14%	22%
Tribal/Conservation	47	23%	55%	38%	9%	19%
Local Interests	63	30%	71%	47%	3%	8%
State/Federal	67	30%	76%	44%	10%	12%

Negative Effects

The three most mentioned negative consequences or concerns of taking woody biomass from forests by stakeholders categorized by region were: loss of wildlife habitat (16%), soil degradation (25%) and loss of organic material (26%) (Table 16). About one third of stakeholders (33%), when grouped by region, did not feel that there would be any negative repercussions as a result of removing woody biomass.

Table 16: Negative consequences by region.

Region	N	Loss of Material	Soil Degradation	Loss of Habitat	No Negative Effects
CP	101	22%	21%	17%	17%
WMC	75	29%	31%	16%	16%
C2P	86	29%	24%	14%	14%
Average	262	26%	25%	16%	16%

Looking at negative consequences by stakeholder group suggests a more nuanced picture. Respondents in the Conservation/Tribal group were more likely to mention soil degradation and loss of wildlife habitat much more often than the Industry group, and somewhat more often than the Local Interests and State/Federal groups (Table 17). The Industry group was more concerned with loss of organic material than the other three stakeholder groups. Participants from the Industry and Local Interests groups mentioned, with more frequency, that there would be no effect or negative consequences related to removing forest residuals for biofuels production.

Table 17: Negative consequences by stakeholder group.

SHG	N	Loss of Material	Soil Degradation	Loss of Habitat	No Negative Effects
Industry	78	30%	24%	10%	40%
Tribal/Conservation	47	21%	34%	28%	19%
Local Interests	64	14%	19%	19%	41%
State/Federal	66	24%	26%	26%	17%

Discussion

Our findings show that stakeholders, regardless of the group they are affiliated with, are more likely to support utilizing woody biomass to produce bioenergy or a refined liquid biofuel. This is an important finding because previous research has indicated that a lack of support is a main obstacle to the successful operation of biofuels production (Rosch & Kaltschmitt, 1999; Upham, 2009a; Walker, 1995).

Looking at respondents' answers to the open-ended questions, we find that there are shared, recurring themes identified. These themes are related to forest conditions and the benefits and potential negative consequences of using woody biomass to produce biofuels. Respondents, in general, were concerned about current excess fuel loads in forests. Stakeholders thought that the regional economy would benefit from removing biomass from forests. Additional benefits, mentioned by all stakeholder groups, were forest fire reduction and creating healthier tree stands. Each group voiced their concern for the negative effects that may occur as a result of removing woody material. These were issues associated with soil degradation, loss of organic material, and loss of wildlife habitat.

Forest Health

We compared responses to the forest conditions/forest health question from the following breakdowns: familiarity with public or private forests, as well as responses by state, region and stakeholder group. While there are a number of similarities across the different categories, there are some distinct differences. For example, over half of respondents familiar with private forests said they were healthy, and these respondents were less concerned with diseases and excess fuels than those who were more familiar with public forests. The difference in perception of forest conditions is likely related to the fact that private forests are managed more actively and frequently than public forests, which can reduce diseases, insect problems and excess fuels (Hubbard 2013).

In looking at responses to the forest health question by state, region and stakeholder group we also find differences and similarities. Comparing respondents by state, we see that those in Idaho and Oregon are more concerned about diseases in general, while respondents in

Montana are most concerned about insect problems. This finding is supported by research indicating that Montana, compared to Idaho and Oregon, has been hit hard by the mountain pine beetle (Raloff 2010). While comparing responses by region, we find similar percentages to those in the state breakdown, and also some differences. For example, there are higher percentages from respondents by region than by state for healthy as well as unhealthy forests. The disease category had lower percentages of responses by region than when broken down by state. Finally, when looking at the data broken down by stakeholder group, we find that respondents in the Industry group have the highest number of responses in all categories. This finding suggests that those respondents in the industry group may have more understanding of forest conditions generally, than the other three categories. In looking at respondents grouped into this category, there are a significant number of respondents affiliated to the forest management and forest products industries.

Positive and Negative Effects of Removing Woody Biomass

To examine responses related to the positive and negative effects of removing woody biomass, we examined stakeholder responses by region and stakeholder group. While there are agreements among respondents by region on the topic of producing healthier tree stands, over one third of respondents from the Columbia Plateau (CP) and Cascade to Pacific (C2P) regions mentioned benefits to economic development. Over one quarter of respondents from the CP and Western Montana Corridor (WMC) saw benefits for increasing renewable energy opportunities. Both the C2P and the WMC regions have stakeholder groups focused on developing wood-to-bioenergy industries in their regions, with some movement being made to utilize forest residuals for bioenergy (e.g., Washington State Forest Biomass Coordination Group, Montana Forest Products Retention Roundtable). However, the CP region has the most experience with implementation of active forest management to support bioenergy developments (Wallowa Resources 2014; Sustainable Northwest 2014). This region, spanning both eastern Oregon and Washington, is taking advantage of federal and state level incentives to harvest, collect and utilize woody biomass from forest residuals. While the emphasis currently is on producing bioenergy (e.g., power), with the infrastructure in place, this region could easily contribute to a wood-based biofuels industry in the Northwest, if it reaches commercial viability. In terms of negative consequences, respondents, when grouped by

region, had similar response rates to loss of organic material, soil degradation and loss of wildlife habitat. However, interestingly enough, the most frequent response, regardless of region, was the perception that there would be little or no negative effects of removing woody biomass for biofuels production.

When looking at the responses to the benefits and potential negative consequences of a wood-based biofuels industry by stakeholder group, apparent differences exist, as suggested by the literature (Benjamin et al., 2009; Peelle, 2001). In particular, the responses from those in the Conservation/Tribal category tend to be focused on the environmental impacts of the project. In terms of benefits, this stakeholder group sees the opportunity for healthier tree stands, and points out negative consequences related to soil degradation and loss of wildlife habitat. Respondents in the Industry group more often mention benefits to the economy as well as increased renewable energy opportunities, and were more likely to suggest that there are no negative consequences associated with removing woody biomass. While State/Federal as well as the Local Interest stakeholders both emphasize the benefit of reduced catastrophic fires, possibly because the financial burden of fighting and suppressing fires largely falls to the federal government, states, and municipalities.

Implications for Planning

A successful wood-based biofuels supply chain in the Northwest depends on a broad network of professionals, communities, and infrastructure. A wood-based biofuels supply chain involves feedstock harvesting, transportation by road and/or rail, mechanical size reduction and densification, pretreatment, conversion, refining, and final delivery to consumers at regional airports. Expected final consumers include the U.S. Air Force and commercial airlines. To reduce capital expenditures, NARA is examining adaptive reuse of idle facilities, as well as co-location with operating facilities. Former pulp, paper and saw mills are suitable sites for biofuels production facilities. Historic timber communities often have such facilities zoned for industrial use, which may have connection to the electrical grid, onsite power production and waste water treatment facilities, and water, air, and/or toxic substance permits. A skilled workforce will be needed, and many resource-dependent communities have a labor force that is able to support biofuels production activities.

By taking action now, communities can be ready to work with investors entering the wood-based biofuels industry. In addition to starting to gauge opinions of key stakeholders within the community, an important first step for planners and economic developers is to inventory active and idle mills and refineries in their region, as well the associated infrastructure (e.g., proximity to rail, ports, pipelines, aviation facilities, etc). Communities can update comprehensive and economic development plans to emphasize their commitment to wood-based biofuels production and renewable energy production. Furthermore, like the City of Gila Bend, Arizona, communities can develop renewable energy overlay zones that expedite the construction of new facilities or the modification of existing ones (Gila Bend, Arizona 2014). The Oregon Department of Energy has developed a model ordinance for siting renewable energy projects that includes wind, solar, biomass, geothermal, cogeneration, and biofuel production plants, as well as electric power transmission and distribution lines (Oregon Department of Energy 2014).

Conclusion

Our findings contribute to the literature related to the social acceptability of a wood-based biofuels industry in the Northwest. Our findings show that stakeholders support utilizing woody biomass to produce bioenergy or a refined liquid biofuel. We also know that stakeholders are concerned about the conditions of private and public forests and see that there are benefits to removing woody biomass to support a liquid biofuels industry that would positively impact forest conditions, regional economies, and reduce fire hazards. However, respondents do have concerns related to the negative impacts on soil and wildlife by the removal of forest residuals. Organizations like NARA are researching the benefits and potential negative effects related to a wood-based biofuels industry. To find out more about NARA, visit the organization's website at: http://nararenewables.org/.

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Chapter 4: Slash and Learn: Stakeholder Knowledge and Worry About a Pacific Northwest Wood-Based Biofuels Industry

Submission Information

This article will be submitted to the *Journal of Rural Sociology* which is a peer reviewed journal that explored inter-disciplinary approaches to emerging issues that are relevant to rural development, the structure of food and agriculture productions, rural-urban linkages, and community revitalization. It includes work from social scientists, policy makers, and agency professionals.

Abstract

In order to understand stakeholder opinions about a woody biomass to biofuel supply chain in the Pacific Northwest, stakeholders in Idaho, Montana, Washington, and Oregon were surveyed to determine their knowledge levels, worries, and questions regarding a woody biomass to biofuel supply. They were also asked information about preferred communication methods. The survey results show stakeholders who feel they know more about using woody biomass to produce liquid biofuels are more supportive of various aspects of the wood to liquid biofuels industry. Main concerns and questions survey participants from all four states and stakeholder groups had related to environmental impacts, the rural economy of their region, and economic feasibility of biomass to liquid fuel projects. This information can be used to create and tailor outreach efforts to better target stakeholders that have concerns, worries, and knowledge gaps through the information outlets that are most meaningful and effective to them.

Introduction

The scientific and economic feasibility of woody biomass as a feedstock for biofuels is being researched and developed in many regions across the U.S.. While the public may have a general understanding of what woody biomass is and where it comes from, many people still have specific questions about the environmental impacts, economic costs and benefits, and what development and production would look like in their specific community and forests. Often times this lack of information and unanswered questions can manifest into opposition to biomass projects (Dale et al., 2013; Rosch & Kaltschmitt, 1999; Upreti, 2004). With this in mind, universities and federal and state agencies are producing educational materials to

inform the public about various aspects of using wood to produce bioenergy and advanced liquid biofuels, such as aviation fuel (Becker, Lowell, Bihn, Anderson and Taff 2014; Ashton, McDonell and Barnes 2012; Colorado State Forest Service n.d.). Because the stakeholders involved and affected by a wood to biofuel supply chain are not a homogeneous group of people, determining effective outreach methods that address a variety of questions and provide information to diverse people in many different areas can be complex.

A survey was developed and administered by the Northwest Advanced Renewables Alliance (NARA) in order to get a better understanding of what questions, concerns, and worries, key stakeholders have in the Northwest United States (Idaho, Montana, Washington, and Oregon). NARA is a collaboration between universities, government, and industry and supported by a $40 million U.S. Department of Agriculture grant awarded to Washington State University in 2011. Taking a holistic approach to building a supply chain within WA, OR, ID and MT based on using forest residuals to make aviation biofuel, the alliance is tasked with increasing efficiency for each supply chain step from forestry operations to conversion processes; creating new bio-based products; providing economic, environmental and social sustainability analyses; engaging stakeholder groups; and increasing bioenergy literacy for students, educators, professionals and the general public.

Research indicates that the level of knowledge stakeholders perceive themselves to have influences their level of support for biofuels industries (Moroney & Laninga, 2014, Monroe & Oxarart, 2010; Qu et al., 2011). The more knowledgeable stakeholders feel and the less questions they have, the more confident they are in making informed decisions relating to biofuels. One of the greatest frustrations felt by stakeholders is that their questions and concerns are not being addressed, which then results in lack of support for bioenergy and biofuels development. Several studies suggest that open communication and more available information about biofuels can increase support for projects (Monroe & Oxarart, 2010; Peelle, 2001; Qu et al., 2011) .

Peelle (2001) named knowledge gaps as one reason for the variation in stakeholder opinions. The study found that large knowledge gaps exist in the realm of public information on biomass, and both agricultural industry stakeholders and environmental stakeholders requested more information on various aspects of industry environmental impacts,

sustainability, net benefit evaluations, and conversion processes. The study also found that "...some of the least sustainable examples of biomass (e.g., mixed solid waste, ethanol from corn kernels) have come to represent the whole of bioenergy for many environmental stakeholders." This results in uncertainties that may weaken support (Peelle, 2001). Qu et al. (2011) found that college aged students in China showed stronger support for renewable energy sources which they knew more about, but expressed interest in learning more about the sources which they knew less, such as woody biomass. The lack of knowledge regarding the environmental impacts of removing woody biomass from the woods has been identified as one potential obstacle when gaining public support for using woody biomass and this, combined with general unawareness of the benefits of using woody biomass, strongly influences the public's perception (Mayfield et al., 2007; Rosch & Kaltschmitt, 1999).

One way to remedy knowledge gaps is to improve communication between stakeholder groups, the biofuels industry, and scientists involved in research and development. Peelle (2001) sites silence and lack of answers as an issue, which have potentially lost supporters from multiple stakeholder groups. The study also explains that stakeholders may become frustrated or lose interest in wood-based biofuels when their inquiries are ignored or remain unanswered. Studies suggest that opening communication with stakeholders as well as the general public is a necessary step in creating a positive atmosphere and a well informed community, both of which are essential to the success of a bioenergy facility (Heiskanen et al. 2008; Peelle, 2001). Studies have found lack of information about woody biomass available to legislators and the general public as a potential barrier and suggest that policy makers, utilities, and other parties involved in the industry should be targets of educational attempts to inform stakeholders of the benefits of using woody biomass (Kraxner, Yang, & Yamagata, 2009; Mayfield et al., 2007; Rosch & Kaltschmitt, 1999). Using education to address these issues will strongly contribute to success in the biofuels industry (Mayfield et al., 2007).

The purpose of this article is to 1) show that stakeholders who identify themselves as having high levels of knowledge about using woody biomass to produce liquid biofuels show a significant difference (p. <.05) in level of agreement/support for a number of issues related to wood-based biofuels compared to those who know less about it, 2) use survey data to identify stakeholders' knowledge level and most frequent questions, concerns, and worries by state and

stakeholder group, and 3) recommend outreach methods based on survey results to answer questions in order to increase understanding among stakeholder groups and by state.

Surveying Methods

A mixed methods survey was developed to explore stakeholder knowledge, concerns, and agreement with topics related to woody biomass feedstock collection, utilization and biofuels production. The survey, consisting of 22 qualitative and quantitative questions, was emailed to stakeholders with vested interest in woody biofuels in Oregon, Washington, Idaho, and Montana. Researchers built the survey specifically to engage a targeted audience of individuals who would be informed on various aspects of the wood to biofuels supply chain and industry and would understand, to some extent, the impacts of the industry. With this is mind, the survey was sent to government officials at local, state, and federal levels; individuals working or involved in the wood products industry; tribal communities, and individuals with environmental conservation interests. Stakeholders were given the option to take the survey online, over the phone, or by mail.

To ensure that each participant interpreted every question the same way, the survey instrument was reviewed by multiple other USDA-NIFA Agricultural and Food Research Initiative grant researchers and then piloted with ten stakeholders who were surveyed in person. Feedback from these ten respondents helped refine the survey into the version that was distributed to the entire stakeholder list. In addition to Likert scaling questions, the survey provided an opportunity for respondents to write specific questions they had about NARA, the wood to biojet conversion process, environmental related issues, and any other concerns they had.

Surveys were sent to 868 stakeholders in Oregon, Washington, Idaho, and Montana; 298 were returned, for a 34% response rate. Researchers categorized participants into four broad groups, which were determined by stakeholder occupation as well their responses to survey questions. The four categories identified are Industry, Conservation/Tribal, Local Interests, and Federal/State government. The participants who completed the survey included 99 individuals from the *Industry* group which includes private foresters, non industrial land owners, primary and secondary products producers, harvesters and haulers, and individuals

who were involved on any level of the forestry industry. Fifty-Six (56) individuals categorized as *Conservation/Tribal* stakeholders which includes members of ENGOs, local resource managers, recreation and wilderness outfitters, and forest or natural resource managers from tribal communities. Eighty-one (81) surveys were received from individuals from the *Local Interest* stakeholder group which includes anyone who operates mainly on a city or county level such as university extension, economic and business development professionals, elected officials, and interested local business investors. Stakeholders categorized into the *State/Federal Government* group completed 62 surveys. This group includes individuals such as public foresters, academic researchers, state or federally employed biologists, as well as federal district rangers (Figure 10).

Broken down by state, Figure 11 shows that eighty-six (86) surveys were received from individuals in Idaho, 85 from Washington, 70 from Oregon, and 57 from Montana.

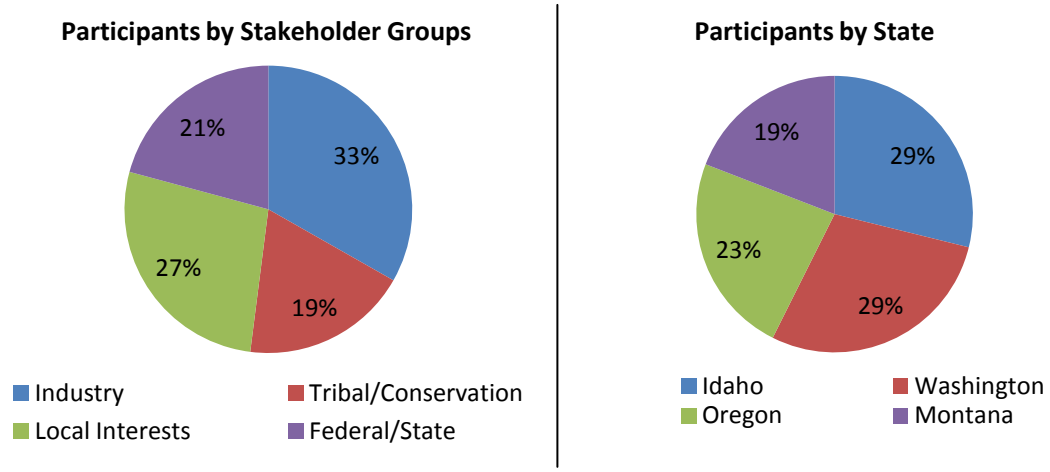

Figure 10: Stakeholder groups of survey participants.

Figure 11: States of survey participants.

Findings

Knowledge Levels

Similar to the literature, we found that the higher level of knowledge a stakeholder said they had about using woody biomass to produce liquid biofuels, the higher level of agreement they

showed with using various sources of woody biomass for biofuels related projects(Moroney & Laninga, 2014; Monroe & Oxarart, 2010).

Stakeholders were asked to give their level of knowledge about using woody biomass to produce liquid fuels by selecting one of four options: “I know a lot,” “I know something,” “I know very little,” and “I know nothing.” They were also asked their level of agreement with several woody biomass sources, uses for woody biomass, and statements about the societal benefits and/or risks of wood-based biofuels. Survey participants were asked to rate their level of agreement on a scale of 1-5 (where 1 was strongly disagree and 5 was strongly agree). When asked what their level of knowledge about using woody biomass to produce liquid biofuels was, stakeholders who said they "know a lot" or "know something" showed a significantly higher level of agreement than those who said they "know very little" and "know nothing" for using woody biomass from three different sources: timber harvest logging residues (p=.009), woody biomass from forest thinning (p=.029), and woody biomass from bug infested and diseased trees (p=.007) (Figure 12).

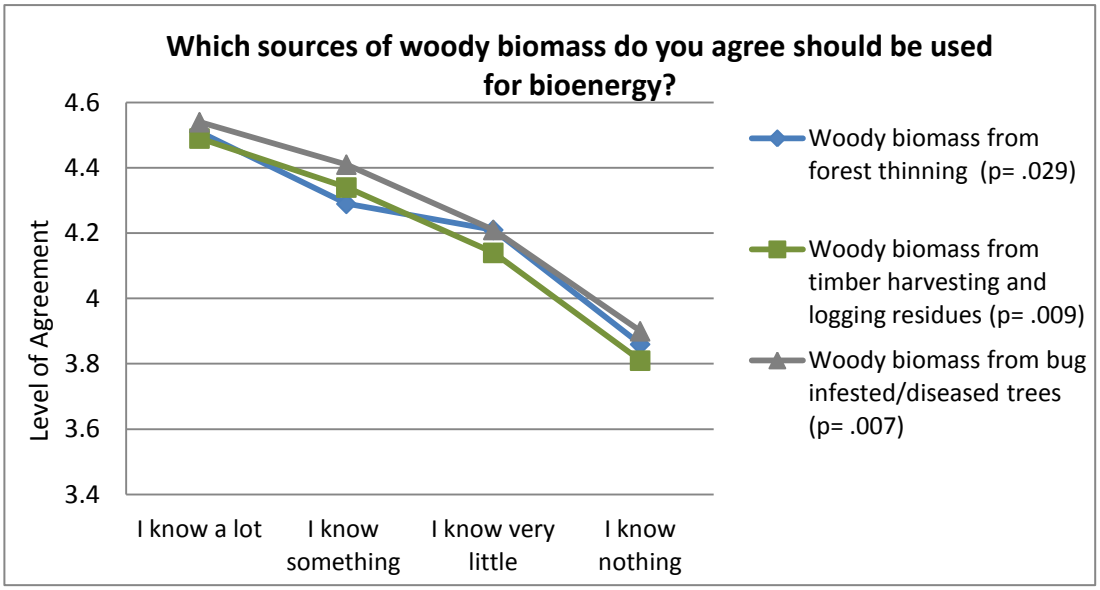

Figure 12: Stakeholder support for *sources* of woody biomass by knowledge level. Level of agreement was measured on a scale of 1-5 where 1 was "strongly disagree" and 5 was "strongly agree."

Similarly, survey participants with higher levels of knowledge also showed significantly higher amounts of agreement with using woody biomass to power a bioenergy power plant (p=.003) and using woody biomass as feedstock for a liquid biofuels refinery (p=.006) (Figure 13).

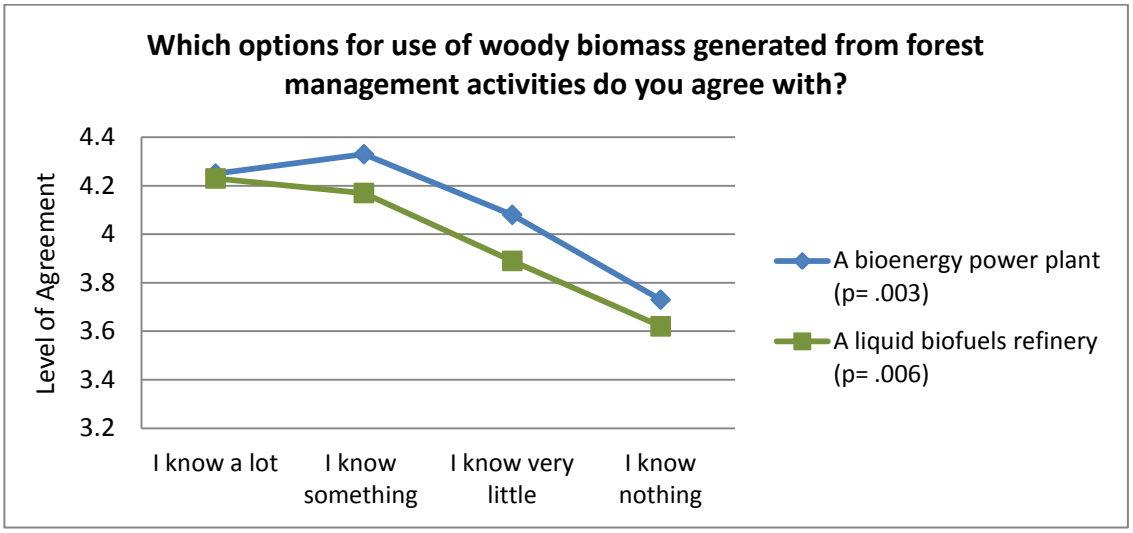

Figure 13: Stakeholder support for *uses* of woody biomass by knowledge level. Level of agreement was measured on a scale of 1-5 where 1 was "strongly disagree" and 5 was "strongly agree."

Survey participants with higher levels of knowledge also showed significantly higher amounts of agreement (p= .006) with the statement "I believe the biofuel industry will have more benefits than risks for society." (Figure 14).

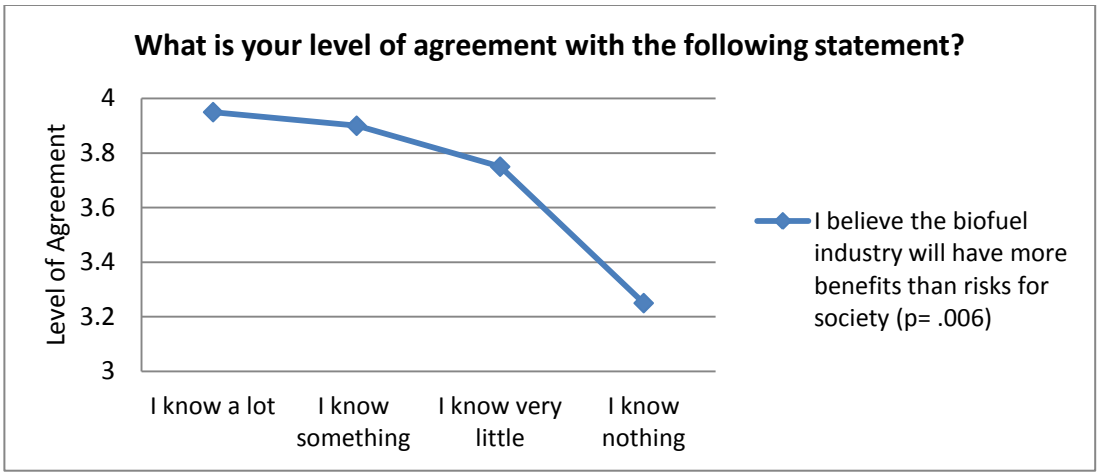

Figure 14: Participant agreement by knowledge level. Level of agreement was measured on a scale of 1-5 where 1 was "strongly disagree" and 5 was "strongly agree."

Questions, Concerns, and Outreach by State

Participants from Idaho, Montana, Washington, and Oregon answered survey questions meant to identify knowledge gaps, worries, and questions in addition to selecting their preferred method of receiving information. While there was variation in topics and concerns expressed between stakeholders from different states and stakeholder groups, there was surprisingly little variation in the methods from which survey participants prefer to get information. Survey findings on knowledge, worries, and questions are examined by stakeholder groups within each state. Organizing our findings by state reflects that fact that much of the outreach function for NARA is being organized by University Extension faculty. These faculty are state-based. The breakdown of the data by state will show Extension faculty which stakeholder groups they should focus on and the key questions stakeholders have in their respective states. This section concludes with an analysis of preferred outreach methods.

Idaho

The topics which Idaho survey participants knew the very least about were using woody biomass to produce liquid biofuels and liquid biofuels in general. Table 18 shows the percentage of survey participants by stakeholder group who answered that they knew "very little" or "nothing" about these two topics.

Table 18: Percentage of Idaho participants who said they knew "very little" or "nothing" about woody biomass related topics.

Industry		Conservation/ Tribal		Local Interests		State/Federal	
Using woody biomass to produce liquid biofuels	46%	Using woody biomass to produce liquid biofuels	52%	Liquid biofuels	35%	Liquid biofuels	42%
Liquid biofuels	33%	Liquid biofuels	45%	Using woody biomass to produce liquid biofuels	22%	Using woody biomass to produce liquid biofuels	35%

Stakeholders were asked their level of worry about 10 different woody biomass related topics. They were given four answer options: “not at all worried,” “a little worried,” “somewhat worried,” and “extremely worried.” The majority of all stakeholders in each group answered they were “somewhat” to “extremely worried” about rural unemployment or the local economy of their region. Forest management practices on public lands were an issue that most Conservation/Tribal stakeholders are worried about, while U.S. dependence on foreign oil was one of the top three issues that Industry, Local Interest, and State/Federal stakeholders all are most worried about. Table 19 shows the top three issues that survey participants most frequently answered that they were “somewhat” or “extremely worried” about.

Table 19: Top three issues by Idaho stakeholder group that survey participants answered they were “somewhat” or “extremely worried” about.

Industry		Conservation/Tribal		Local Interests		State/Federal	
U.S. dependence on foreign oil	90%	Forest management practices on public lands in the PNW	80%	Rural unemployment in my region	91%	U.S. dependence on foreign oil	85%
Local economy of my region	77%	Local economy of my region	76%	U.S. dependence on foreign oil	86%	Forest health in the PNW	75%
Forest health in the PNW	71%	Rural unemployment in my region	75%	Local economy of my region	82%	Local economy of my region	71%

The final question of the survey read "What questions do you have about using woody biomass for making biofuels?" Respondents are most concerned about the economics of

biofuels, mentioning most frequently the competitive cost of biofuel production, while regulation and policy questions about using public lands and federal fuel subsidies was a close second. Other frequently asked questions included transportation of the feedstock, feedstock composition and source, and the actual process of turning the feedstock into liquid fuel.

Montana

Using woody biomass to produce liquid biofuels was one topic which all four stakeholder groups in Montana knew less about. Many Industry, Conservation/Tribal, and Local Interest stakeholders said that they knew very little to nothing about liquid biofuels, while 12% of State/Federal stakeholders said that they knew "very little" or "nothing" about forest health issues (Table 20).

Table 20: Percentage of Montana participants who said they knew "very little" or "nothing" about woody biomass related topics.

Industry		**Conservation/Tribal**		**Local Interests**		**State/Federal**	
Using woody biomass to produce liquid biofuels	42%	Liquid biofuels	33%	Using woody biomass to produce liquid biofuels	40%	Using woody biomass to produce liquid biofuels	12%
Liquid biofuels	39%	Using woody biomass to produce liquid biofuels	14%	Liquid biofuels	39%	Forest health issues	12%

At least 75% of survey participants from Montana in all stakeholder groups answered they are "somewhat" to "extremely" worried about the local economy of their region. A large percentage of Industry, Conservation/Tribal, and Local Interest stakeholders are worried about forest health in the Pacific Northwest (Table 21).

Table 21: Top three issues by Montana stakeholder group that survey participants answered they were "somewhat" or "extremely worried" about.

Industry		Conservation/Tribal		Local Interests		State/Federal	
Forest health in the Pacific Northwest	94%	Forest health in the Pacific Northwest	100%	U.S. dependence on foreign oil	95%	Rural unemployment in my region	100%
Local economy of my region	83%	Local economy of my region	86%	Local economy of my region	84%	U.S. dependence on foreign oil	100%
Rural unemployment in my region	76%	Finding renewable fuel sources	86%	Forest health in the Pacific Northwest	84%	Local economy of my region	75%

The questions which were most frequently asked by Montana stakeholders were about the economics of using woody biomass for liquid biofuels and "When can we start?" They also asked questions about the source of the feedstock and the environmental impacts of harvesting woody biomass.

Washington

Similar to stakeholders in other states, using woody biomass to produce liquid biofuels as well as liquid biofuels were the top two topics that Washington stakeholders knew less about. While all stakeholders groups in Washington had these two categories in common, Industry professionals from this state seemed to know slightly more than participants in other stakeholder groups. Only 26% of Industry stakeholders answered that they knew "very little" to "nothing" about using woody biomass to produce liquid biofuels, where all other stakeholder groups had at least 45% of participants answer that they knew "very little" to "nothing" about this topic (Table 22).

Table 22: Percentage of Washington participants who said they knew "very little" or "nothing" about woody biomass related topics.

Industry		Conservation/Tribal		Local Interests		State/Federal	
Using woody biomass to produce liquid biofuels	26%	Using woody biomass to produce liquid biofuels	56%	Liquid biofuels	57%	Liquid biofuels	45%
Liquid biofuels	23%	Liquid biofuels	50%	Using woody biomass to produce liquid biofuels	54%	Using woody biomass to produce liquid biofuels	27%

At least 75% of Washington survey participants in all stakeholder groups are “somewhat” to “extremely worried” about U.S. dependence on foreign oil. A large percentage of Industry, Conservation/Tribal, and Local Interest stakeholders are worried about the economy of their region or rural unemployment, while at least 67% of Industry, Conservation/Tribal, and State/Federal stakeholders are worried about forest health in the Pacific Northwest (Table 23).

Table 23: Top three issues by Washington stakeholder group that survey participants answered they were “somewhat” or “extremely worried” about.

Industry		Conservation/Tribal		Local Interests		State/Federal	
U.S. dependence on foreign oil	83%	Rural unemployment in my region	76%	Local economy of my region	79%	Forest health in the Pacific Northwest	91%
Local economy of my region	68%	Forest health in the Pacific Northwest	71%	Rural unemployment in my region	75%	U.S. dependence on foreign oil	91%
Forest health in the Pacific Northwest	67%	U.S. dependence on foreign oil	65%	U.S. dependence on foreign oil	75%	Decreasing fossil energy reserves	73%

Of the questions posed by Washington stakeholders, economic concerns came up most frequently in addition to many questions about feedstock, regulation and policy issues, and project scale.

Oregon

Oregon stakeholders responses were similar to the trend in the other states. The issues which they possessed the least amount of knowledge about were liquid biofuels and using woody biomass to produce liquid biofuels. While over 28% of Industry, Conservation/Tribal, and Local Interest stakeholders answered that they knew "very little" to "nothing" about these topics, State/Federal stakeholders seemed to be more informed with 19% answering that they knew "very little" to "nothing" about using woody biomass to produce liquid biofuels, and only 10% said that they knew very little to nothing about liquid biofuels (Table 24).

Table 24: Percentage of Oregon participants who said they knew "very little" or "nothing" about woody biomass related topics.

Industry		**Conservation/Tribal**		**Local Interests**		**State/Federal**	
Liquid biofuels	50%	Using woody biomass to produce liquid biofuels	40%	Liquid biofuels	36%	Using woody biomass to produce liquid biofuels	19%
Using woody biomass to produce liquid biofuels	28%	Liquid biofuels	33%	Using woody biomass to produce liquid biofuels	29%	Liquid biofuels	10%

At least 83% of all Oregon survey participants in all stakeholder groups are "somewhat" to "extremely worried" about forest health in the Pacific Northwest, and at least 71% of all stakeholders are concerned about the local economy of their region. (Table 25).

Table 25: Top three issues by Oregon stakeholder group that survey participants answered they were "somewhat" or "extremely" worried about.

Industry		**Conservation/Tribal**		**Local Interests**		**State/Federal**	
Forest management practices on public lands in the Pacific Northwest	92%	Forest health in the Pacific Northwest	100%	Local economy of my region	93%	Rural unemployment in my region	90%
Forest health in the Pacific Northwest	83%	U.S. dependence on foreign oil	89%	Rural unemployment in my region	93%	Forest health in the Pacific Northwest	85%
Local economy of my region	80%	Local economy of my region	80%	Forest health in the Pacific Northwest	93%	Local economy of my region	71%

The majority of questions that Oregon stakeholders had concerned economic issues surrounding the wood to biofuels supply chain. Other questions which were asked often, but less frequently, included questions about environmental impacts and regulation and policy questions.

Outreach

While educators and researchers should vary the content of the information they wish to distribute based on the state and stakeholder group they are trying to reach, they may not have to vary their outreach methods. Over 90% of all stakeholders felt that a project website was the best form of communication followed by fieldtrips, newspaper, email newsletter, community meetings, and workshops which at least three out of four stakeholders felt were effective forms of distributing information (Figure 15).

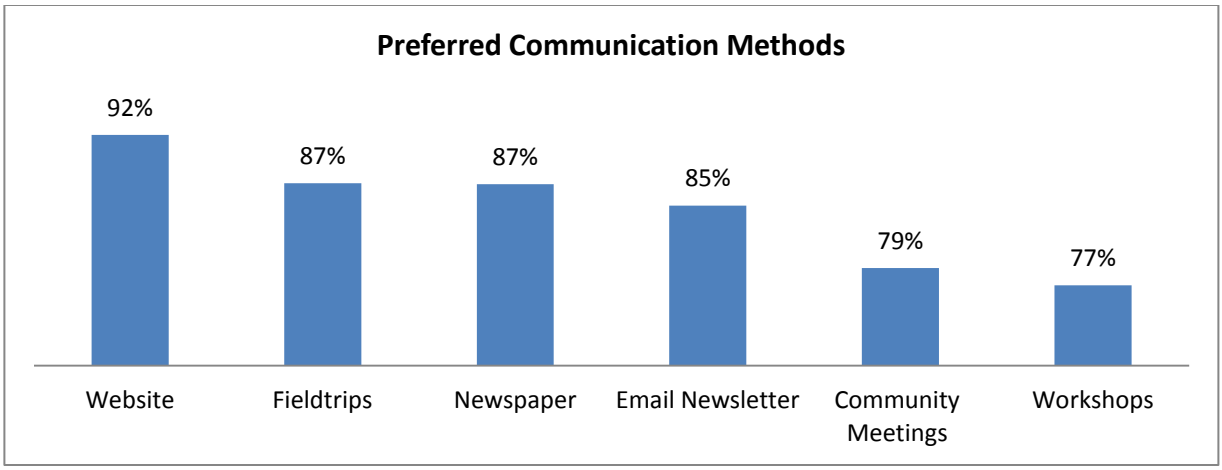

Figure 15: Survey participants' preferred methods of communication.

Discussion and Comparisons

Even though knowledge levels differed by state, it was apparent that a noteworthy percentage of stakeholders in every state felt that they knew very little to nothing about liquid biofuels and using woody biomass to produce liquid biofuels. This information combined with the questions that stakeholders wrote on their surveys shows a need for education on the topics of what liquid biofuels are, how they are made, and what kind of feedstock can be used to produce liquid biofuels. Outreach efforts should target stakeholder groups that had the highest percentage of participants that said they knew "very little" to "nothing" about these topics (Table 26). It would also be useful to address these topics by framing them in the context of the issues that stakeholders are most concerned about.

Table 26: Least knowledgeable stakeholder group by state.

State	Stakeholder Group
Idaho	Conservation/Tribal
Montana	Local Interests & Industry
Oregon	Conservation/Tribal & Local Interests
Washington	Conservation /Tribal & Industry

Even though the level of worry varied by stakeholder group in each state, two topics emerged as being important to all groups within a state: forest health in the Pacific Northwest and the local economy. In addition to these topics, Idaho and Washington stakeholders showed high levels of worry about U.S. dependence on foreign oil. In Montana and Oregon, stakeholders are also worried about rural unemployment. Outreach efforts should highlight the potential effects of a woody biomass to biofuels supply chain on local economies and forest health in all regions, and discuss the potential biofuels have for replacing traditional fossil fuels, especially in Idaho and Washington.

Out of all the questions written in by survey participants, the most frequently asked questions in every state regarded the economics of a wood to biofuels project: “Is it economically feasible?” “Is it economically sustainable?” “Will government subsidies be needed to make biofuels economically competitive?” Idahoans were concerned about policy issues, which might arise mainly around access to roads and resources on public lands, possibly because over 50% of Idaho is public lands. Montanans indicated that beyond economic questions, their greatest concern was getting the industry up and running; the second most frequently asked question by Montana stakeholders was "When can we start?" In Washington stakeholders are concerned about the source of the feedstock and policies that might affect harvesting it. Oregon stakeholders asked the most questions about environmental impacts of harvesting and producing liquid biofuels.

When it comes to methods that stakeholders' prefer to get information from, it is apparent that many want easy and convenient ways to access information- internet, newspaper, and emailed newsletters, but they also want venues where they can interact with experts and ask questions--field trips, community meetings, and workshops. Other studies suggest that opening lines of communication can potentially raise support for biofuels projects (Monroe & Oxarart, 2010; Peelle, 2001; Qu et al., 2011) .

Conclusion

It is apparent that stakeholders who feel they know more about using woody biomass to produce liquid biofuels are more supportive of various aspects of the wood to liquid biofuels

industry. It is also clear that there are concerns, worries, questions, and knowledge gaps in the Northwest when it comes to using woody biomass to produce liquid biofuels. Data from this survey shows that while there is some variation in answers by state and stakeholder groups, many stakeholders share the same worries and have the same questions about the economic feasibility of this type of project and what sort of an impact they can expect to see on their communities and the environment. This information will aid and expand NARA's ongoing outreach efforts that currently include traditional extension activities such as workshops, webinars, conferences, and newsletters.

We recommend that the NARA outreach and education teams, and similar wood to biofuels projects, use this information to create and tailor outreach efforts to better target stakeholders that have concerns, worries, and knowledge gaps through the information outlets that are most meaningful and effective to them. In addition to making information easily accessible through the NARA website and newsletter, articles about project information and impacts should be published in newspapers of the communities involved. It is also clear that an emphasis should be placed on two way communication between stakeholders and researchers. This can be achieved by hosting more workshops and fieldtrips in addition to community information sessions.

Knowing that questions and concerns exist in the Northwest U.S. and that stakeholders want to have access to this knowledge as well as venues where they can ask questions will be helpful in guiding outreach efforts to close knowledge gaps and quell concerns regarding the emergence of a woody biomass to liquid biofuels industry in the Northwest.

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Chapter 5: Conclusion

This study set out to explore opinions of stakeholders in the Pacific Northwest regarding a woody biomass to liquid biofuel supply chain. As environmental issues such as climate change are becoming more widely recognized, so are mitigation strategies. Both public and private entities are looking at biofuels, specifically wood based biofuels, as a way to lessen their environmental impact. NARA is examining the feasibility of producing liquid biofuels and bio-based products from forest residuals in Oregon, Washington, Idaho, and Montana. While the existing body of research on woody biomass to biofuels projects is growing, there are gaps in the literature in regard to stakeholder knowledge, opinions, and worries. This study sought to address these gaps by asking:

1. What differences in knowledge, perceptions, and opinions do we see between stakeholder groups, demographic factors, and by region? Specifically, what relationship exists between stakeholders' perceived level of knowledge and the social acceptability of a wood based biofuels supply chain?

2. What knowledge gaps exist among different SHG and how can these be remedied in order to increase stakeholder support?

Findings

The in depth findings from this study can be found in Chapters 2, 3, and 4 which discuss both quantitative and qualitative findings as well as make suggestions for effective methods of outreach. However, information from all three chapters is synthesized below to show a complete picture of stakeholder knowledge and perceptions about a woody biomass to biofuel supply chain in the Pacific Northwest.

Research Question 1

The first research questions asks "What differences in knowledge, perceptions, and opinions do we see between stakeholder groups (SHG), demographic factors, and by region? Specifically, what relationship exists between stakeholders' perceived level of knowledge and the social acceptability of a wood based biofuels supply chain?"

Many subtle and significant differences were apparent through survey analysis, but what was more prominent were high levels of support for many topics related to wood based biofuels harvesting, production, and operations. Through regression analysis, we found that strongest indicator of support of a wood based biofuels supply chain was an understanding of perceived benefits, and, although each stakeholder group identified different benefits in qualitative answers, what is important is that each group did see benefits. Conservation/Tribal stakeholders tended to identify environmentally positive impacts of the project such as the opportunity for healthier tree stands. Respondents in the Industry group more often mention benefits to the economy as well as increased renewable energy opportunities. State/Federal as well as the Local Interest stakeholders both emphasized the benefit of reduced catastrophic fires. These findings were similar to and confirm what was found in our analysis of the qualitative survey data as well. Other benefits that all stakeholders tended to agree with included improvement of the rural economy, employment opportunities, general environmental benefits, and reduced dependence on foreign oil.

Despite understanding that there are many benefits of biomass removal and utilization, all stakeholders also understood that there are potentially negative impacts. Conservation/Tribal stakeholders were the most concerned about negative consequences related to soil degradation and loss of wildlife habitat. They were also the least supportive of utilizing woody biomass as a feedstock to supply a bioenergy power plant or a liquid biofuels refinery. Industry stakeholders were the most likely to suggest that there are no negative consequences associated with removing woody biomass, and the most supportive of using woody biomass as a feedstock for a bioenergy power plant or a liquid biofuels refinery. State/Federal stakeholders were most worried about rural unemployment and the local economy of their regions, and the most supportive of utilizing woody biomass in all applications including for a saw mill, value added products, pellet manufacturing, and to supply a bioenergy power plant or a liquid biofuels refinery.

We saw high levels of support across regions and in all states, but we also saw that survey participants in general are worried about forest health in the Pacific Northwest. I was pleased to see that many of the concerns listed were place based given the study was done using

communicative planning theory which emphasizes stakeholders as experts in their own region. Even though stakeholders from all four states are worried about forest health, participants in Montana and Oregon were the most concerned about forest condition in their states. While more Montanans listed healthy forest conditions in their state than any other state, they more than doubled the percentage of stakeholders in any other state in identifying insect problems in their forests. Oregonians had the highest percentage of stakeholders who said that there is excess fuel in their forests. Through regression we identified that concerns about forest health, mainly related to general forest health as well as management practices on both public and private lands, is negatively correlated with support. This means that the higher level of concern about forest health that stakeholders have, the more accepting stakeholders are of biofuel activities in their region. This is due to the understanding that management practices, which can include removal of woody biomass, can contribute to forest health. This high level of concern about forest health across the board shows that survey participants understand that a wood to biofuel supply chain in their region will affect forest health.

It was apparent in the surveys that many stakeholders understood benefits and had worries, but it was also apparent that many of these worries were the result of a lack of knowledge or a feeling of incomplete understanding. Stakeholders who said they knew a something or knew a lot about using woody biomass to produce liquid fuels showed a significantly higher level of agreement for using various sources of woody biomass, with using woody biomass to power a bioenergy power plant or a liquid biofuels refinery, and said that the biofuels industry had more benefits than risks for society.

When each piece of research presented in the three chapters of this dissertation is synthesized into one single description, it shows that stakeholders in the Pacific Northwest are generally supportive of many elements of a wood based biofuel supply chain and that there are specific knowledge gaps, mainly about liquid biofuels in general, that need to be addressed in order to quell concerns of stakeholders and give them a more in depth understanding of possible benefits. Both these elements, concerns and perceived benefits, are strong indicators of support for a liquid biofuel supply chain in the Pacific Northwest.

Research Question 2

The existing body of literature about bioenergy suggests that knowledge gaps negatively impact the support for biofuels projects(C. a. Mayfield et al., 2007; Peelle, 2001; Qu et al., 2011; Rosch & Kaltschmitt, 1999). Because of this, our second research question asked "What knowledge gaps exist among different stakeholder groups and how can these be remedied in order to increase stakeholder support?"

Survey results show that there is some variation between the levels of knowledge by stakeholder group, but overall, the topics that they knew little about were the same. Survey participants most frequently said they knew very little or nothing about liquid biofuels and using woody biomass to produce liquid biofuels in all states. Conservation/Tribal stakeholders knew the least about these topics in Idaho, but in Montana it was Local Interest and Industry stakeholders who knew the least. Conservation/Tribal as well as Local Interests in Oregon knew the least, and Conservation/Tribal and Industry stakeholders knew the least in Washington. Out of all four stakeholder groups, State/Federal stakeholders said they knew the most about these topics.

The questions that survey participants wrote in themselves mainly concerned environmental impact questions and economic feasibility questions. It is important to note similarities in questions, but also the differences. Because communicative planning theory says that stakeholders are experts about their own region, the questions asked by them are an important reflection of issues and values specific to their location. In addition to these economic and environmental topics, Idahoans asked questions about policy issues about removing woody biomass from public lands, Washington stakeholders asked about feedstock sources, Oregon stakeholders asked the most questions about environmental impacts of harvesting and producing liquid biofuels, and Montanans asked "When can we start?"

Knowing that knowledge level can create a significant difference in level of agreement with aspects of a wood based biofuel supply chain, it is important that knowledge gaps are remedied and stakeholder questions are answered. Participants from all states and stakeholder groups had similar preferred means of communication. They all wanted easy ways to access project information, and the top three avenues they wanted to get information through were: websites, newspapers, and emailed newsletters. They were also all interested in venues where

they could receive information first hand *and* be able to ask questions. Over 77% of stakeholders said that fieldtrips, community meetings, and workshops were preferred and effective ways for them to receive information.

Knowing that knowledge gaps exist among all stakeholder groups in all states about liquid biofuel and its production, as well as environmental and economic impacts of a liquid biofuel supply chain, it is important for outreach materials to target these areas. With very little difference between stakeholders' preferred methods of communication, it appears that the best ways to get this information to stakeholders is through (in order of preference) websites, fieldtrips, newspapers, emailed newsletters, community meetings, and workshops. Our results are congruent with existing literature in that it is important to make information easily available to stakeholders, and essential to make communications two way between stakeholders and program scientists/management/educators(Heiskanen et al., 2008; Owens & Driffill, 2008; Peelle, 2001; Upreti & van der Horst, 2004).

Recommendations for Further Research

CAAM

While not included in this dissertation, the information gathered through the surveying process should be used to contribute to a Community Asset Assessment Model (CAAM), which uses biogeophysical data (infrastructure, natural resources, distance, etc.) and retrospective analysis of social asset data to determine communities' potential to play a role in the biofuels supply chain. This model can be used to identify communities that are both physically and socially ready to support aspects of the biojet supply chain based on information generated from surveying as well as biogeophysical and social asset data. These three data sets can be triangulated to identify areas of high potential at a county level. To further refine, validate and calibrate the CAAM, ground-truthing should be conducted in communities that show high potential in playing a role in the biofuels supply chain.

In-person Interviews

It would be beneficial to explore themes identified through survey analysis more in depth through in-person interviews of stakeholders within the study region. Questions for these interviews should specifically address ideas and concepts that are identified as important by

VBN theory in order to get at the root of how stakeholder opinions will translate into supply chain participation. Interview questions should address who and what stakeholders think will be affected by a wood based biofuels industry, if they think that participating in this industry will directly affect them as individuals in their region, and what strategies will be most affective towards changing attitudes and behaviors.

Research Limitations

This study has offered an in depth evaluation of stakeholder perspectives regarding using woody biomass to produce liquid biofuels in the Pacific Northwest. As a direct consequence of the methodology used, the study encountered several limitations, which should be considered.

One of the main limitations faced while conducting this research was getting stakeholders to complete the survey. Generally people only respond to surveys which they see as relevant to themselves (Dillman, 2000). In the case of our survey, stakeholders who either do not know about the NARA project or about woody biomass may not have found the survey pertinent to their job or industry and declined to participate. It is safe to assume that participants who are more knowledgeable about biomass or the NARA project, as well as those who work directly with biomass, were more inclined to complete the survey.

Another challenge was reaching participants. Many of the stakeholders we hoped to target work in industries where they are not checking email daily, or advertising their email as a way to contact them, so reaching them with the survey link was a challenge. Because of this, the proportion of those who participated in the survey might be bias towards individuals who have access to email as part of their job. In an attempt to remedy this the survey was also sent out as a hard copy in order to reach those participants for which email is not a viable way of communication.

Surveying in general has limitations including the ones listed above. Only so much information can be gleaned from the short, semi-structured answers that surveys provide. If this study was done using in person interviews instead or in addition to surveys, it would have been possible for the researcher to ask follow up questions to expand on the answers given by participants on the survey.

Time was another limiting factor. Surveying is an extensive process and it took a lot of time to collect stakeholder names, send survey requests, and follow up with individuals. Initially we followed up with every individual via phone during Phase 1 of surveying. This was not a realistic option when we reached Phase 2 because of the large numbers of participants to which we sent the survey.

Finally, some of the questions asked have their own limitations. One section of the survey asked participants to rate their level of knowledge. The data collected from these questions only shows participants' *perceived* level of knowledge and not their *actual* level of knowledge. In order to understand what participants know in relation to one another we would have to give a fact-based test. Because we did not do this, we cannot tell how much survey participants actually know, just how much they think they know. Along these same lines, we do not know where they get their information from or how much time they have spent researching the topics we asked about.

Conclusion

The results from this study indicate that while there are knowledge gaps that should be remedied and specific stakeholder asked questions that need to be addressed, overall, stakeholders from all stakeholder groups and states see benefits of the biofuels industry and show high levels of support for a woody biomass to biofuels supply chain in the Pacific Northwest.

Appendix 1: Phase 1 Survey Email

Dear (Participant Name),

I am a research assistant working on the Northwest Advanced Renewables Alliance (NARA) project, which is examining ways to turn one of Pacific Northwest's most plentiful commodities—wood and wood waste—into jet fuel. You can find out more about the NARA project at the website: www.nararenewables.org.

The NARA Stakeholder team is inviting you to participate in a survey developed to examine people's understanding of and support for using woody biomass to produce biofuels.

Our survey aims include:

Increasing regional stakeholders' awareness of the NARA project and providing opportunities to become more involved

Identifying topics for education and outreach materials

Finding communities/regions interested in participating in the biomass to biofuels supply chain and providing them with technical support to examine regional opportunities.

The survey can be completed online or over the telephone.

To participate, please reply to this email with your preferred method.

Online:
We will send you the survey link with a passcode.

Telephone:
We will schedule a date and time to call you and complete the survey over the telephone.

Please indicate dates/times that you are available the week of April 1-5. We will contact you with a specific time/date for your telephone interview.

Thank you in advance for your willingness to complete our survey. We look forward to hearing your perspective on this topic. If you have questions, you can direct them to Dr. Tammi Laninga at the University of Idaho. She can be reached by phone at 208-885-7117 or laninga@uidaho.edu.

Best Regards,

Jillian Moroney
University of Idaho
NARA RA

Appendix 2: Phase 1 Reminder Email

Hello,

I just wanted to remind you that the North West Advanced Renewables Alliance (NARA) is conducting a survey and we would greatly appreciate your participation. To find out how you can participate either via phone or web, please review the following email. Thank you so much, I am looking forward to hearing back from you.

Best Regards,

Jillian Moroney
University of Idaho
NARA RA

Appendix 3: Phase 2 Survey Email

Dear(Participant Name),

You have been recommended as a stakeholder with valuable insight to complete a survey about biofuels. The survey examines people's understanding of and support for using woody biomass to produce biofuels. **By completing this survey, you will be entered in a drawing for one of 12 sweatshirts (valued at $60 each) embroidered with the logo of your university of choice.** If you complete the survey in the next week, your name will be entered three times into the drawing, twice if you complete the survey in the next two weeks, and once for completing it before July 31, 2013.

Here is the survey link:

http://survey.libarts.wsu.edu/remark/rws5.pl?FORM=NorthwestAdvancedRenewablesAllianceSurvey

Here is your passcode:

(Participant Code)

Our survey aims include:

Increasing regional stakeholders' awareness of biofuels projects in the Pacific Northwest and providing opportunities to become more involved

Identifying topics for education and outreach materials

Finding communities/regions interested in participating in the biomass to biofuels supply chain and providing them with technical support to examine regional opportunities.

If you would **prefer to take this survey over the phone,** please email me back with the days and times you are available so we can set up an appointment.

This project has been approved by the University of Idaho's Institutional Review Board. Your participation is completely voluntary and will remain confidential. All data will be aggregated and not directly attributed to individuals.

We appreciate your willingness to complete our survey. If you have any questions, please contact Soren Newman at newman@uidaho.edu or Tammi Laninga at laninga@uidaho.edu.

Best regards,

Jillian Moroney
University of Idaho
Research Assistant

Appendix 4: Phase 2 Survey Reminder

Dear (Participant Name),

As a reminder, you have been recommended as a stakeholder with valuable insight to complete a survey about biofuels. The survey examines people's understanding of and support for using woody biomass to produce biofuels. **By completing this survey, you will be entered in a drawing for one of 12 sweatshirts (valued at $60 each) embroidered with the logo of your university of choice.** If you complete the survey in the next week, your name will be entered twice into the drawing, and once if you choose to complete the survey before July 31, 2013.

Here is the survey link:

http://survey.libarts.wsu.edu/remark/rws5.pl?FORM=NorthwestAdvancedRenewablesAllianceSurvey

Here is your passcode:

(Participant Code)

Our survey aims include:

Increasing regional stakeholders' awareness of biofuels projects in the Pacific Northwest and providing opportunities to become more involved

Identifying topics for education and outreach materials

Finding communities/regions interested in participating in the biomass to biofuels supply chain and providing them with technical support to examine regional opportunities.

If you would **prefer to take this survey over the phone,** please email me back with the days and times you are available so we can set up an appointment.

This project has been approved by the University of Idaho's Institutional Review Board. Your participation is completely voluntary and will remain confidential. All data will be aggregated and not directly attributed to individuals.

We appreciate your willingness to complete our survey. If you have any questions, please contact Soren Newman at newman@uidaho.edu or Tammi Laninga at laninga@uidaho.edu.

Best regards,

Jillian Moroney
University of Idaho
Research Assistant

Appendix 5: Phase 3 Mail Survey

NARA Stakeholder Survey:

Assessing Stakeholder Knowledge and Perceptions Regarding

the Utilization of Woody Biomass for Biofuels

The Northwest Advanced Renewables Alliance (NARA) is conducting this survey as part of an ongoing project determining the feasibility of a woody biomass to liquid jet fuel supply chain. For more information about the NARA project, please visit: *www.nararenewables.org*.

All of your answers will remain confidential;

we will aggregate data for analysis, and will not attribute responses to individuals.

By completing this survey, your name will be entered into a drawing for one of 12 university embroidered sweatshirts valued at $60 each. Before you begin the survey, please specify your preferred university and sweatshirt size.

I would like the chance to win a sweatshirt from:	**X-Small**	**Small**	**Medium**	**Large**	**X-Large**	**XX-Large**
Montana State University						
Oregon State University						
Penn State University						
University of Idaho						
University of Montana						
University of Washington						
Washington State University						
Western Washington University						

Below are definitions of terms that we use in the survey. Please review these before starting

the survey, so that you are familiar with the definitions we are using for these terms.

Feedstock: Raw materials used to produce bioenergy, biofuels and other bioproducts.

> **Woody Biomass:** Wood residues (e.g., tree limbs, tree tops, brush, and other material derived from forest vegetation); small diameter trees; urban wood waste; construction and demolition debris.
> **Biofuel:** Liquid fuels made from biomass resources.
> **Bioenergy:** Renewable energy, including biofuel, heat and electricity, produced from biomass.
> **Pre-processing depot:** Facility where woody biomass is sorted and prepared for shipping to a conversion plant.
> **Conversion plant:** Facility where condensed woody biomass (e.g., wood chips or pellets) is converted into biofuels.
> **Peer Group:** Consists of people who share common interests, similar views and/or similar professional backgrounds.

First, some background questions

1. Before completing this survey, had you heard about the Northwest Advanced Renewables Alliance (NARA) project looking at making liquid biofuels from woody biomass in the Pacific Northwest? (*please circle the appropriate response*)

Yes No Not Sure

If yes, how?

2. Please indicate *with a check mark,* how much you know about each of the following

items.				
I know a lot/nothing about:	I know a lot about	I know something about	I know very little about	I know nothing about
a. The NARA Project				
b. Renewable energy				
c. Liquid biofuels				
d. Using woody biomass to produce liquid biofuels				
e. Forest health issues				
f. Forest management practices				

3. Below is a list of topics. Please indicate with a check mark, which best describes your level of worry for each one.				
I am worried/not worried about:	Extremely worried	Worried	A little worried	Not at all worried
a. Local economy of my region				
b. Adverse environmental impacts related to woody biomass removal in the Pacific Northwest				
c. The current direction of forest management practices on public lands in the Pacific Northwest				
d. Rural unemployment in my region				
e. Decreasing fossil fuel reserves				
f. Adverse environmental impacts related to liquid biofuels production in the Pacific Northwest				
g. The current direction of forest management practices on private lands in the Pacific Northwest				
h. The ability to find renewable fuel sources				
i. The current condition of forest health in the Pacific Northwest				
j. U.S. dependence on foreign oil				

Next, questions focused on your views about forest management issues

4. Please provide the name/location of the forests with which you are most familiar. Are these forests public or private? (*please circle public or private*)

5. How would you describe the current forest conditions in the forests you listed in questions 4?

6. What are the positive effects, if any, of removing woody biomass? Please explain.

7. What are the negative effects, if any, of removing woody biomass? Please explain.

8. Below is a list of statements. Please indicate *with a check mark*, which best describes your level of agreement/disagreement with each one.					
I agree/disagree that:	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
a. Woody biomass from *timber harvesting* (logging residues – i.e., tops and branches) should be used for bioenergy.					
b. Woody biomass from *forest thinning* should be used for bioenergy.					
c. Woody biomass from *bug infested/diseased trees* should be used for bioenergy.					
d. Public forests should be managed for forest health to reduce beetle kill and wildfire risks.					
e. Public forests should be managed for production of forest products.					
f. When cutting trees on public lands only small diameter trees should be removed.					

This section of the survey focuses on uses for woody biomass

9. Below is a list of options for using woody biomass generated from forest management activities. Please indicate *with a check mark,* which best describes your level of agreement/disagreement with each statement.					
Woody biomass should be used to supply:	Strongly Disagree	Disagree	Neither Agree nor disagree	Agree	Strongly Agree
a. A bioenergy power plant					
b. A wood pellet production plant					
c. A sawmill					
d. A wood products manufacturer (i.e., furniture, interior paneling)					
e. A liquid biofuels refinery					
f. Woody biomass should not be removed from the forest, regardless of its potential use					

This section deals with liquid biofuels specifically

10. Below is a list of statements concerning liquid biofuels. Please indicate *with a check mark,* which best describes your level of agreement/disagreement with each statement.					
I support/oppose:	Strongly Disagree	Disagree	Neither Agree nor disagree	Agree	Strongly Agree
a. Increased use of liquid biofuels will off-set climate change.					
b. The biofuel industry could improve the rural economy.					
c. Using biofuels will reduce U.S. dependence on foreign oil.					
d. The biofuel industry will have more benefits than risks for the society.					
e. The refineries in my region would provide employment opportunities.					
f. Biofuels have a lower environmental impact than conventional (fossil) fuels.					

This section of the survey addresses environmental impacts and monitoring.

Below is a list of statements concerning environmental impacts and monitoring. Please indicate *with a check mark,* which best describes your level of agreement/disagreement with each statement.					
I agree/disagree:	Strongly Disagree	Disagree	Neither Agree nor disagree	Agree	Strongly Agree
11. Environmental impact monitoring on PUBLIC lands is vital to the success of biofuel projects.					
12. Environmental impact monitoring on PRIVATE lands is vital to the success of biofuel projects.					
13. I trust the following to monitor PUBLIC forests used as a potential source for woody biomass.					
a. The U.S. Forest Service					
b. State Forester					
c. A local environmental group					
d. A national environmental group					
e. University scientists					
f. Independent 3rd party certifier (i.e., Forest Stewardship Council [FSC])					

14. I trust the following to monitor PRIVATE forests used as a potential source for woody biomass.	Strongly Disagree	Disagree	Neither Agree nor disagree	Agree	Strongly Agree
a. A local environmental group					
b. A national environmental group					
c. University scientists					
d. Private forest landowner					
e. Independent 3rd party certifier (i.e., Forest Stewardship Council [FSC])					
15. As long as periodic monitoring is being done, I trust the results.					

In this next section, we are examining community opinions related to using biomass for biofuels.

16. Below is a list of statements. Please indicate *with a check mark,* which best describes your level of support/opposition to the following statements.					
I support/oppose:	Strongly Oppose	Oppose	Neither Support nor Oppose	Support	Strongly Support
a. Obtaining woody biomass from public forests in my state					
b. Siting a pre-processing depot facility in my county					
c. Siting a conversion facility in my county					
d. Siting a biofuels refinery in my county					
e. Selling biofuels within the US that are derived from woody biomass.					

17. Stakeholders in my region will probably hold common opinions on:	Strongly Disagree	Disagree	Neither Agree nor disagree	Agree	Strongly Agree
a. The amount of woody biomass available in my state					
b. The parameters of woody biomass removal					
c. The definition of a healthy forest					
d. The best location for a conversion plant					

18. Which stakeholders are less likely to hold a common opinion on these topics?

19. Below are a number of methods that could be used to increase community awareness about a biofuels project. Please indicate *with a check mark,* which of the following communication methods you would prefer to use to receive information.		
I prefer:	Yes	No
a. Brochures		
b. Newspaper articles		
c. Webinars		
d. Public Displays (e.g., at library)		
e. Project newsletter – mailed hardcopy		
f. Project newsletter - emailed		
g. Social media (Facebook, Twitter, Tumblr)		
h. Website		
i. Community meetings		
j. You Tube video		
k. Project listserve		
l. Workshops		
m. Field Trips		

A few questions about you and your peer group

20. Who do you consider to be part of your peer group?

21. Approximately what percent of your peers feel the same way you do about converting woody biomass to liquid biofuels?

22. Please share the name and contact information of other stakeholders in your region who you feel would help us to develop a complete perspective on this issue.

Finally, some questions about you

23. Please select the ONE stakeholder group that best represents you.

	Forestry & Forest Products Industry/Associations
	Harvesters/Haulers
	Primary Products
	Secondary Products
	Tribal Organizations/Communities
	Non Industrial Landowners
	Industrial Landowners
	Chemical Industry
	Bio refinery
	Petroleum Industry
	Renewable Energy
	Transportation
	ENGOs
	Research/Academic Institutions
	Local Resource Management Associations
	Local Influential Leaders
	Interested Local Businesses/Investors
	Wilderness Outfitters/Recreation Organizations
	City/Town Government
	County/State Government - EDD, DNR
	Federal Agencies: USDA, National Parks, BLM

24. Year you were born? _____

25. Your gender (*please circle*): Male Female

26. What is your current job title? _____

How long have you been in your current job? (*please circle*)

Less than 2 years 2-5 years more than 5 years

Please provide your prior job title and approximate length of time.

27. What is your highest level of education? *(please circle)*

HS degree College degree Graduate degree

28. How would you describe yourself politically? *(please circle)*

Very Liberal
Moderately Liberal
Liberal Leaning
Conservative Leaning
Moderately Conservative
Very Conservative
Independent

29. Zipcode: _____

30. NARA is a 5-year project, to assess its impacts, would you be willing to be contacted in the future for a follow-up interview about the NARA project and the topic of biofuels?

Yes No

Thank you for your help.
Is there anything you would like to add to this topic that we have not covered in this survey? We would appreciate any comments.

Thank you

To return your completed questionnaire, simply mail it back in the enclosed postage-paid envelope to:
NARA Stakeholder Survey

Conservation Social Science Department

University of Idaho

875 Perimeter Drive, MS 1139

Moscow, ID 83844-1139

On behalf of the Northwest Advanced Renewables Alliance, thank you for completing this survey. Your participation and thoughtful answers are sincerely appreciated. To stay up to date on the NARA project, please visit the website at: *www.nararenewables.org*.

Appendix 6: Phase 3 Reminder Postcard

Biofuels Survey | **Reminder**

You may recall receiving a survey regarding biomass recently. We would like to remind you how important your participation is for our survey project. If you have already responded, "thank you" and our apologies for this reminder. If you have not yet responded it would be very helpful to us if you would please complete the survey and place it in the pre-paid return envelope. The survey should take no more than 15 minutes of your time. The information you provide will remain CONFIDENTIAL and will provide valuable information regarding stakeholder understanding and support for using woody biomass to produce biofuels. If you would prefer to take the survey on-line, here is the link: [coming].

Questions? Please contact us at NARASurvey@uidaho.edu or 208-885-7117.

NARA

Northwest Advanced Renewables Alliance

Thank You for your help, we value your opinion and will follow up with a phone call within the next week if we do not hear back from you.