

Family Forest Owners and Bioenergy: Toward a blueprint “buy-in” plan
for feedstock production

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A thesis
submitted in partial fulfillment of the
requirements for the degree of

Master of Science

University of Washington

2013

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Program Authorized to Offer Degree:

Environmental and Forest Sciences

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Abstract

Family Forest Owners and Bioenergy: Toward a blueprint “buy-in” plan for feedstock production.

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The emerging biofuels industry in Washington State presents enormous opportunities for family forest owners. Feedstock supply from family forest owners will likely be necessary to supplement the supply of forest residuals from public lands and large-scale private industrial properties. Like every innovation, feedstock-for-biofuels production is challenging. It entails new and different private forest management practices. In this thesis I explore family forest owner perceived motivations and constraints towards producing feedstock for biofuel. Through key informant interviews with pertinent biofuel scientists and “experts” I explored state of the art feedstock production practices and perceived opportunities and barriers to implementation by family forest owners. I also conducted focus group interviews with family forest owners to uncover the factors that explain interviewees’ perceived motivations and constraints to feedstock production. Salient motivations included land management benefits, economics, ecological sustainability, and the potential for small-scale, decentralized infrastructure. Salient constraints included ecological concerns, perceived lack of economic feasibility and market uncertainty, and conflicts with forest values and management preferences. Interviews were also moderated to reveal a descriptive sense of the impact, probability and penetration of feedstock

production practices. Interviewees expressed that centralizing and transporting biomass might be the most impactful, or constraining practices. Transporting biomass off-site also had the least penetration of feedstock production behaviors. However, interviewees expressed a higher likelihood of supplying forest residuals if this barrier could be overcome by having someone pick up residuals from their property. We discuss the use of these interview findings in the development of a blueprint social-marketing plan and how a pilot of that can be implemented to enhance the adoption and diffusion of feedstock production by private family forest owners and farmers in Washington.

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ACKNOWLEDGEMENTS

I owe thanks to the many people who helped me in the completion of this thesis. First, to my advisor, Stanley Asah, who guided me through the research and thesis writing process and provided help and input along the way. I also want to thank my committee members, Sergey Rabotyagov and Luke Rogers, who provided valuable insights, questions, and edits for my research. Many thanks are also owed to Rick Dunning and Ron Munroe, who helped me connect with forest owners and significantly expanded my understanding of forest management.

I cannot express enough gratitude to my fellow Human Dimensions of Natural Resource Management Lab colleagues, particularly Caitlin Singer, Miku Lenentine, Ellen Weir, and Cassandra Garcia. Thanks to all of you for providing such a warm, helpful, and collaborative learning environment. My research was surely much improved through your input and advice, and I appreciate each of your contributions to my professional, academic, and personal development.

Finally, I want to thank my parents, John and Gina Lee, my sisters, Brooke Marton and Gayla Lee, and also my partner, Wesley Godon. Thank you for your love and support.

1. LITERATURE REVIEW

1.1 Wood-based Bioenergy

Concerns over climate change and energy dependence necessitate investment in alternative fuel sources. Washington State's entire oil supply is imported and half of Washington's greenhouse gas emissions come from fossil fuel consumption for transportation uses (Mason et al., 2009). Additionally, federal policy requires an increase in renewable fuels. Recognizing the need for energy dependence, the Renewable Fuel Standard (RFS) was established under the Energy Policy Act of 2005 to mandate increased blending of renewables, including cellulosic biofuel, in transportation fuels (U.S. Environmental Protection Agency (US EPA), 2009). According to the US Department of Energy, "Cellulosic feedstocks are non-food based feedstocks that include crop residues, wood residues, dedicated energy crops, and industrial and other wastes (U.S. Department of Energy (DOE), 2013)." The RFS requires 36 billion gallons of renewable fuel for blending in transportation fuel by 2022, 16 billion of which must be from cellulosic biofuel (US EPA, 2009).

Forest residuals, including logging slash (limbs, tree tops, rotten logs, stumps), wood salvaged from forest thinning, and non-marketable timber can be harvested from forests and converted into liquid transportation fuels (Mason et al., 2009). Washington State has an abundance of forest biomass (Mason, 2009), that could potentially meet the growing demands for renewable transportation fuels.

1.2 Family Forest Owners and Bioenergy

To make the biofuel production process economically feasible, large conversion facilities will be needed, necessitating a consistent and reliable supply of feedstock (Mason et al., 2009). In total, 9.4 million acres in Washington, or 43% of total state forested land, are

privately owned (Erickson & Rinehart, 2005). Of that private forest land, 3.2 million acres (34%) are owned by small groups and individuals (Erickson & Rinehart, 2005). I refer here to these small groups and individuals as family forest owners, defined as “families, individuals, trusts, estates, family partnerships, and other unincorporated groups of individuals that own forest land” (Butler, 2008). Feedstock supply from family forest owners will likely be necessary to supplement the supply of forest residuals from public lands and large-scale private industrial properties.

Family forest owners have diverse attitudes, values and motivations (Bengston et al., 2011) and those diverse attitudes, values, and motivations have implications for how to most effectively tailor educational programs, communicate with, and provide services for family forest owners (Finley & Kittredge, 2006; Kendra & Hull, 2005; Joshi & Mehmood, 2011). Social factors, including forest landowner attitudes and management decisions, could constrain woody biomass availability. Butler et al. (2010) estimated the availability of wood in the Northern United States based on biophysical and social constraints and found that social factors, particularly landowner attitudes toward harvesting, led to the greatest reduction in availability (landowner attitudes accounted for 52.7% of the total 61.9 % reduction for both biophysical and social availability). Clearly, forest owner attitudes and decisions are likely to be the constraining factors in ensuring woody biomass supply. Through this study we will uncover those social factors and decisions that could constrain or motivate family forest owners to supply feedstock for biofuel.

Several survey studies in the Northern and Southern United States have looked at the role of private forest owner attitudes, beliefs, and management objectives with respect to their willingness to harvest or supply woody biomass for bioenergy. The results of these studies

show, in general, that forest owners with larger acreages are more likely to harvest or supply biomass for bioenergy (Paula et al., 2011; Joshi & Mehmood, 2010). These studies also found that younger family forest owners, those with wildlife management objectives, and higher education levels were more likely to harvest or supply biomass for bioenergy (Gruchy et al., 2011; Joshi and Mehmood 2010). Not surprisingly, higher prices for biomass are also associated with an increased likelihood of harvesting or supplying biomass for bioenergy (Markowski-Lindsey et al., 2012) A more comprehensive overview of these studies is provided in the following paragraphs.

Paula et al. (2011) found that most family forest owners were willing to supply feedstock for biofuels in the form of timber and wood residues from forests. Paula et al. (2011) also found several variables that positively correlated with landowner willingness to supply feedstock: land acreage, active forestland management, addressing energy security and climate change, benefiting the local economy, and the existence of a market for biofuel feedstock. Income generation from timber sales was the strongest motivator for forest owner willingness to provide feedstock (Paula et al., 2011). Joshi and Mehmood (2010) found that demographic characteristics, forest acreage, type of tree species and certain ownership objectives (timber production and wildlife management objectives) influenced forest landowner willingness to supply woody biomass for bioenergy. Younger landowners and those with larger acreages, wildlife management objectives, and higher education were more likely to supply biomass for bioenergy. Interestingly, those who valued timber production were less likely to supply biomass for bioenergy. Markowski-Lindsay et al. (2012) found a low likelihood of participation in harvesting residual biomass (range between 7-17% based on hypothetical economic return scenarios) by family forest owners in Massachusetts. The likelihood of harvesting residual

biomass was associated with the following: A higher price for biomass, those planning to harvest on their property, those involved in state tax programs, and those who believed biomass harvesting would have a positive economic impact were all more likely to harvest residual woody biomass. Those with written management plans, on the other hand, were less likely to harvest biomass. Interestingly, belief of negative environmental impacts of biomass harvesting was not a significant predictor of the likelihood of biomass harvest (Markowski-Lindsay et al. (2012).

Differing from other studies, Gruchy et al. (2011) found that land acreage and age had a negative correlation with biofuel harvesting. Landowners that rated aesthetics as important were less likely to want to utilize woody biomass for bioenergy over a standard clear-cut. Forest landowners that believed wildlife habitat management to be important and those with high education levels, on the other hand, were more willing to utilize logging residuals for biofuel. Those that considered financial benefit important were also more likely to be willing to supply logging residues over a traditional clear-cut in two scenarios where supplying residues would provide equal the amount of money as clear cutting and when it would provide additional income (as opposed to the third scenario where landowners would lose money).

While it is important to study attitudes and willingness towards producing feedstock for biofuel, these social-psychological factors alone do not give us a clear picture of family forest owners' behavior. According to the Theory of Planned Behavior, behavior depends on both behavioral intentions (formed by attitudes and subjective norms) and perceived behavior control (Ajzen, 1991). In other words, just because a forest owner holds positive attitudes towards supplying forest residuals and a willingness or intention to do so, does not necessarily mean that they will engage in the activities required to supply forest residuals. External barriers (real or

perceived) might prevent family forest owners from supplying forest residuals, even though they might be willing to do so, and would therefore need to be addressed. It is important, then, not only to look at social-psychological factors, such as attitudes and intentions, but also the structural-material factors that could motivate or constrain forest owners in producing feedstock. In this study, we uncover both social-psychological and structural-material motivations and constraints to family forest owners engaging in feedstock production practices.

Additionally, supplying forest residuals for biofuel is not one activity, but rather a series of activities or behaviors that lead to the delivery of biomass at a conversion facility. Trees must be harvested. Residual biomass must be centralized, loaded on a vehicle, and transported. Each of these activities represents the potential for unique barriers. Sequencing the series of behaviors that lead to the end-state behavior of delivery of residual biomass at a conversion facility can be used to more accurately identify and orient the alleviation of barriers (McKenzie-Mohr, 2011). Through this research, we identify the series of behaviors necessary for family forest owners to supply feedstock for biofuels and we provide a descriptive sense of the impact, probability, and penetration of behaviors to determine which of these behaviors should be targeted for intervention.

Most of the research on family forest owners and bioenergy is conducted through survey studies. The primarily quantitative nature of these studies could be a disadvantage for understanding the depth of family forest owner views on supplying feedstock for biofuel. Closed ended surveys of family forest owner motivations have been shown not to capture the range of salient motivations and values that have been elicited in open-ended questions (Bengston et al. 2011). Using qualitative methods can provide a contextual, more nuanced understanding and perspective on salient motivations and constraints as expressed through

attitudes, values, and beliefs (Patton, 2005; Kasey & Krueger, 2009). In this study we use qualitative methods-key informant interviews and focus groups- to explore the depth of family forest owner motivations and constraints towards producing feedstock for biofuel.

Finally, to the authors' knowledge, to date, no studies have looked at family forest owner views on participating in a wood-based biofuels industry in the Pacific Northwest. Family forest owner involvement in supplying feedstock for bioenergy needs to be studied on a regional scale as there are likely to be important differences in landowner attitudes and values, infrastructure needs, and physical landscape across regions. In a comparison between one study of family forest owners in Massachusetts and one in Minnesota, beliefs about biomass harvesting impacts and benefits, land acreage, management objectives, and willingness to supply biomass for biofuel all differed between the two regions (Markowski-Lindsey et al., 2012). In this study, we address family forest owner motivations and constraints towards feedstock production in Washington State.

1.3 Attitudes, Attitude Change, and Behavior

Supplying biomass for biofuel will entail new and different management practices for family forest owners. Knowledge about family forest owner attitudes, perceptions and beliefs is important for understanding their willingness to produce feedstock for biofuels. Attitudes refer to an individual's subjective evaluation (positive or negative) of a phenomenon or object (Maio & Haddock, 2009) Attitudes and beliefs may need to be altered to encourage family forest owners to produce feedstock for biofuel. Attitude change, while important, is not enough to change behavior. Attitudes and persuasion as well as additional behavior change theories are discussed in the following sections.

Attitudes and Persuasion:

According to Katz (1960), reasons for holding or changing attitudes have to do with the functions that these attitudes perform. Persuasive attempts to change attitudes must match the psychological motivational basis behind why people hold particular attitudes. Katz (1960) describes the reasons why people hold the attitudes that they do, by identifying four functions that attitudes perform- Utilitarian, ego-defensive and enhancement, value-expressive and knowledge. *Adjustive or utilitarian attitudes* are held to help the individual maximize rewards and minimize penalties. *Ego-defensive attitudes* are held to help preserve the self-concept. *Value-expressive attitudes* allow for the expression of an individual's values or beliefs. These attitudes help the individual confirm that they are in fact the person they believe themselves to be.. *Knowledge attitudes* are those that give meaning and structure to the individual for understanding the world.

Understanding attitude function is important for persuasion and understanding how to change attitudes. According to the functional approach, persuasive appeals to change attitudes will be successful to the extent that the appeals match the underlying motivations for holding these attitudes (Katz, 1960; Wood, 2000; Shavitt & Nelson, 2002). Understanding psychological motivations for holding an attitude can lead to better prediction of how attitudes will change. Attitudes need to be aroused and modified based on the function that they perform for the individual. This knowledge can be used to determine points of intervention and develop appropriate methods for attitude change.

According to Katz (1960), "The functional approach is the attempt to understand the reasons people hold the attitudes they do. The reasons, however, are at the level of psychological motivations and not of the accidents of external events and circumstances". In other words, the functional approach attempts to understand attitudes at the internal,

psychological motivational level. While this approach is certainly important for persuasion, it does not take into consideration external motivations or barriers that could encourage or prevent individuals from engaging in a behavior. Behavior change theory can be useful for understanding other factors in addition to attitudes that can be used to change behaviors.

Attitudes and Behavior

The **Theory of Reasoned Action** and the **Theory of Planned Behavior** seek to explain premeditated behaviors or actions. According to the Theory of Reasoned action, deliberate behaviors are (directly) predicted by behavioral intentions, which are in turn formed by attitudes and subjective norms (Ajzen, 1991). Attitudes refer to an individual's subjective evaluation of a given behavior as good or bad. Individuals generally form positive attitudes towards behaviors believed to have positive consequences and negative attitudes towards behaviors associated with beliefs of negative consequences. Subjective norms refer to beliefs about how important others view a given behavior (Ajzen, 1991). In line with the Theory of Reasoned action, if an individual has a positive attitude toward a behavior and has normative beliefs that important others believe engaging in this behavior to be positive, they are likely to form an intention to engage in the behavior. These intentions are the greatest predictor of the likelihood that an individual will engage in the behavior (Ajzen, 1991). It is important to mention, however, that while attitudes and subjective norms form behavioral intentions, they do not directly predict behavior.

The Theory of Planned Behavior builds on the Theory of Reasoned Action by including the concept of perceived behavior control, or an individual's beliefs about their ability to carry out or perform a given behavior (Ajzen, 1991). According to the Theory of Planned Behavior,

behavioral intentions are formed by attitudes and subjective norms, as well as perceived behavioral control. In other words, an individual may think engaging in a given behavior is good and may have normative beliefs that others think engaging in the behavior is good, but certain barriers (perceived or real) may keep them from engaging in the behavior. Perceived behavioral control affects behavior both indirectly and directly. According to this model, perceived behavior control both indirectly predicts behavior (does the individual view themselves as capable of performing behaviors) by affecting behavioral intention, as well as having a direct effect on behavior (regardless of perception, can the individual actually perform the behavior) (Ajzen, 1991).

In some cases, attitudes and beliefs will need to be altered to help facilitate behavior change. However, as the Theory of Planned Behavior suggests, working towards changing attitudes, beliefs, and perceptions is not enough to change behavior. Both perceptions of self-efficacy and external barriers could keep family forest owners from participating in producing feedstock for biofuel. Therefore, efforts to encourage family forest owners to produce feedstock must address motivations and constraints on both internal and external levels. Efforts must be tailored on a social-psychological level to alter attitudes, beliefs, and perceptions. They must also work on a structural-material level to remove barriers that could prevent family forest owners from supplying feedstock for bioenergy.

1.4 Social Marketing

Extension service and other outreach efforts will need to be prepared to encourage family forest owners to produce feedstock for biofuels once a market for biofuels production is secured. Social marketing, the application of conventional marketing techniques and the psychology of persuasion to encourage pro-social behavior change (Kotler & Lee, 2007), can be

a useful tool for encouraging forest management practices among private forest owners (Butler et al., 2007). The social marketing approach is a systematic method for effecting behavior change, which involves identifying perceived motivations, constraints, and competing behaviors of a targeted audience to the target behavior and developing a strategy to encourage behavior change (Kotler & Lee, 2007).

1.4.1. Behavior Selection

Social marketing is ultimately about behavior change. The success of a social marketing program is determined by its ability to bring about a change in behavior. An important component of social marketing is to determine which specific behavior(s) should be targeted. Ideally, chosen behaviors would be those with the greatest capacity to bring about change. McKenzie-Mohr (2011) outlines a systematic method for determining which behaviors are the best to target- those with high impact, high probability of adoption, and low penetration. *Impact* refers to how impactful each of the behaviors will be in bringing about the desired results. *Probability* refers to the likelihood that people will take part in each of the behaviors. *Penetration* refers to the proportion of the target audience that is already participating in the behaviors (McKenzie-Mohr, 2011). The process begins with developing a list of all the non-divisible end-state behaviors that could contribute to your desired goal. *End-state* behaviors are the behaviors that actually produce the desired outcome (e.g. delivery of forest residuals to a conversion facility), whereas *prior behaviors* refers to those behaviors that lead to the end-state behavior (harvesting trees, piling debris, chipping biomass). *Non-divisible behaviors* refer to those actions or behaviors that cannot be divided further. From the list of end-state, non-divisible behaviors, the impact, probability and penetration of each behavior can be determined.

According to McKenzie-Mohr (2011) selected target behaviors should be high impact, have a high probability of adoption, and low penetration.

Our study differs from McKenzie-Mohr's (2011) framework, since only one possible end-state behavior exists- supplying forest residuals for biofuel conversion. However, this behavior selection strategy can be usefully adapted to choose which of the prior behaviors in the series of potential feedstock production behaviors should be targeted. We have adapted the meaning of impact, probability and penetration, described as follows: For the purposes of our study, *impact* refers to determining which of the feedstock production practices is most impactful or constraining to family forest owners. *Probability* refers to the likelihood that respondents would participate in feedstock production behaviors if certain feedstock production constraints were removed. *Penetration* refers to the extent to which family forest owners are already taking part in potential feedstock production or supply practices.

1.4.2 Barrier and Benefit Identification

Once behaviors are selected, perceived barriers and benefits to target behaviors can be determined. Encouraging individuals to engage in a target behavior can be viewed in terms of exchange (Bagozzi, 1974). According to exchange theory, in order for an exchange to take place (in this case, encouraging forest owners to adopt feedstock production practices), people must perceive the benefits of engaging in the exchange to be greater than the costs. The main beneficiary can be a third party such as the environment or society, not just the individual taking part in the exchange (Bagozzi, 1974). An understanding of motivations, constraints, and behaviors is integral to developing a social marketing strategy and promoting a favorable exchange. This social marketing strategy involves lessening or removing barriers to the target

behavior, while also reducing motivations and perceived benefits to competing behaviors. Likewise, motivations and perceived benefits to target behaviors are simultaneously increased while barriers to competing behaviors are increased (Kotler & Lee, 2007; McKenzie-Mohr, 2011). In this manner, target behaviors become seen as more favorable or desirable, while competing behaviors are viewed as less desirable. McKenzie-Mohr (2011) also highlights several potential behavior change tools for use in a social marketing strategy: commitments, social diffusion, prompts, effective communication and convenience. The social marketing approach can help to increase initial forest landowner “buy-in” and thus speed the diffusion and adoption of sustainable biofuels production.

1.5 Objectives

The goal of this study was to produce a blueprint social marketing plan to aid in outreach and extension efforts in the diffusion and adoption of biofuels technologies and practices by family forest owners. To achieve this goal I addressed the following objectives:

- (i) Determine the sequence of behaviors (prior through end-state) necessary for family forest owners to produce feedstock for biofuel
- (ii) Determine family forest owner motivations and constraints to biofuel feedstock production.
- (iii) Assess the impact, probability and penetration of feedstock production practices and behaviors.
- (iv) Discuss how a social marketing plan could use that knowledge to encourage family forest owners to produce feedstock for biofuel.

To address these objectives I conducted one-on-one and focus group interviews with family forest owners and key informants. The remainder of this thesis is presented in the form of a publishable manuscript. In this manuscript, I provide an introduction followed by an explanation of my methods. I then present the results of this study and suggest ways that family

forest owner motivations and constraints to feedstock production can be incorporated into a social marketing strategy.

Title: Family Forest Owners and Bioenergy: Toward a blueprint “buy-in” plan for feedstock production.

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2. INTRODUCTION:

Concerns over climate change and energy dependence necessitate investment in alternative fuel sources. Washington State’s entire oil supply is imported and half of Washington’s greenhouse gas emissions come from fossil fuel consumption for transportation uses (Mason et al., 2009). Additionally, federal policy requires an increase in renewable fuels. The Renewable Fuel Standard (RFS), established under the Energy Policy Act of 2005, mandates increased renewables in transportation fuels (US Environmental Protection Agency, 2009). The RFS requires 16 billion gallons of renewable fuel for blending in transportation fuel by 2022 (US Environmental Protection Agency, 2009). Using woody biomass as cellulosic feedstock could reduce energy dependence and meet RFS requirements. Forest residuals, including logging slash (limbs, tree tops, rotten logs, stumps), wood salvaged from forest thinning, and non-marketable timber can be also be harvested from private forests and converted into cellulosic biofuels (Mason et al., 2009). To make the biofuel production process economically feasible, large conversion facilities will be needed, necessitating a consistent and reliable supply of feedstock (Mason et al., 2009) In total, 9.4 million acres in Washington, or 43% of total state forested land, are privately owned (Erickson & Rinehart, 2005). Of that private forest land, 3.2 million acres (34%) are owned by small groups and individuals (Erickson & Rinehart, 2005). Feedstock supply from small-scale private forest owners, referred

to here as family forest owners, will likely be necessary to supplement the supply of forest residuals from public lands and large-scale private industrial properties.

Several survey studies in the Northern and Southern United States have looked at the role of private forest owner attitudes, beliefs, and management objectives with respect to their willingness to harvest or supply woody biomass for bioenergy. The results of these studies show, in general, that forest owners with larger acreages are more likely to harvest or supply biomass for bioenergy (Paula et al., 2011; Joshi & Mehmood, 2010). These studies also found that younger family forest owners, those with wildlife management objectives, and higher education levels were more likely to harvest or supply biomass for bioenergy (Gruchy et al., 2011; Joshi and Mehmood 2010). Not surprisingly, higher prices for biomass are also associated with an increased likelihood of harvesting or supplying biomass for bioenergy (Markowski-Lindsey et al., 2012).

Family forest owners have diverse attitudes, beliefs, values and motivations (Bengston et al., 2011) and those diverse attitudes, values, beliefs, and motivations have implications for how to most effectively tailor educational programs, communicate with, and provide services for family forest owners (Finley & Kittredge, 2006; Kendra & Hull, 2005; Joshi & Mehmood, 2011). Forest owner attitudes and management decisions have a significant impact on their willingness to participate in a wood-based bioenergy industry (Butler et al, 2010). Clearly knowledge about family forest owner attitudes, perceptions and beliefs is important for understanding their likelihood of producing feedstock for biofuels. While attitudes and beliefs do not directly predict behavior, they do influence the intentions of individuals to engage in a behavior, which subsequently predicts their behavior (Ajzen, 1991; Maio & Haddock, 2009). Knowledge of forest owners can also be useful for informing technological development of

biofuels production to ensure that it is more acceptable to family forest owners. Additionally, in some cases, attitudes and beliefs will need to be altered to encourage family forest owners to take part in biofuel feedstock production practices.

Most of the research on family forest owners and bioenergy has been conducted through survey studies. The primarily quantitative nature of these studies could be a disadvantage for understanding the depth of family forest owner views on supplying feedstock for biofuel. Closed ended surveys of family forest owner motivations have been shown not to capture the range of salient motivations and values that have been elicited in open-ended questions (Bengston et al. 2011). Using qualitative research methods can provide a more nuanced, contextual understanding and perspective on salient motivations and constraints as expressed through attitudes, values, and beliefs (Patton, 2005; Kasey & Krueger, 2009). In this study we use qualitative methods-key informant interviews and focus groups- to explore the depth of family forest owner motivations and constraints towards producing feedstock for biofuel.

The present literature on private forest owners and bioenergy primarily addresses forest owner willingness or likelihood of harvesting or supplying forest residuals for bioenergy. While it is important to study attitudes and willingness towards producing feedstock for biofuel, these social-psychological factors alone do not give us a clear picture of family forest owners' behavior. Behavior depends on both behavioral intentions (formed by attitudes and subjective norms) and perceived behavior control (Ajzen, 1991). In other words, just because a forest owner holds positive attitudes towards supplying forest residuals and a willingness or intention to do so, does not necessarily mean that they will engage in the activities required to supply forest residuals. External barriers (real or perceived) might prevent family forest owners from supplying forest residuals, even though they might otherwise be willing to do so. Working

towards changing attitudes, beliefs and perceptions is not enough to change behavior and a targeted behavior change strategy, addressing both social-psychological and structural-material motivations and constraints, is therefore likely necessary.

Extension service and other outreach efforts will need to be ready to encourage family forest owners to produce feedstock for biofuels once a market for biofuels production is secured. Social marketing, the application of conventional marketing techniques and the psychology of persuasion to encourage pro-social behavior change (Kotler & Lee, 2007), can be a useful tool for encouraging forest management practices among private forest owners (Butler et al., 2007). The social marketing approach is a systematic method for effecting behavior change, which involves identifying perceived motivations, constraints, and competing behaviors of a targeted audience to the target behavior (Kotler & Lee, 2007).

Social marketing is ultimately about behavior change. The success of a social marketing program is determined by its ability to bring about a change in behavior. An important component of social marketing is to determine which specific behavior(s) should be targeted. Ideally, chosen behaviors would be those with the greatest capacity to bring about change. McKenzie-Mohr (2011) outlines a systematic method for determining which behaviors are the best to target through intervention programs- those with high impact, high probability of adoption, and low penetration. According to McKenzie-Mohr (2011) Impact refers to how impactful each of the behaviors will be in bringing about the desired results. Probability refers to the likelihood that people will take part in each of the behaviors. Penetration refers to the proportion of the target audience that is already participating in the behaviors (McKenzie-Mohr, 2011). The process begins with developing a list of all the non-divisible end-state behaviors that could contribute to your desired goal. End-state behaviors are the behaviors that actually

produce the desired outcome (e.g. delivery forest residuals to a conversion facility), whereas prior behaviors refers to those behaviors that lead to the end-state behavior (harvesting trees, piling debris, chipping biomass). Non-divisible behaviors refer to those actions or behaviors that cannot be divided further. From the list of end-state, non-divisible behaviors, the impact, probability and penetration of each behavior can be determined. According to McKenzie-Mohr (2011) selected target behaviors should be high impact, have a high probability of adoption, and low penetration.

Our study differs from McKenzie-Mohr's (2011) framework, since only one possible end-state behavior exists- supplying forest residuals for biofuel conversion. However, this behavior selection strategy can be usefully adapted to choose which of the prior behaviors in the series of potential feedstock production behaviors should be targeted. Supplying forest residuals for biofuel is not one activity, but rather a series of activities or behaviors that lead to the delivery of biomass at a conversion facility. Trees must be harvested. Residual biomass must be centralized, loaded on a vehicle, and transported. According to McKenzie-Mohr (2011) it is important to address the series of prior behaviors in addition to end-state behaviors, since each of these activities represents the potential for unique barriers. We have adapted the meaning of impact, probability, and penetration as a framework for determining which feedstock production practices to target for intervention, described as follows: For the purposes of our study, impact refers to determining which of the feedstock production practices is most impactful or constraining to family forest owners. Probability refers to the likelihood that respondents would participate in feedstock production behaviors if certain feedstock production constraints were removed. Penetration refers to the extent to which family forest owners are already taking part in potential feedstock production or supply practices.

Encouraging individuals to engage in a target behavior can be viewed in terms of exchange. According to exchange theory, in order for an exchange to take place (in this case, encouraging forest owners to adopt feedstock production practices), people must perceive the benefits of engaging in the exchange to be greater than the costs. The main beneficiary can be a third party such as the environment or society, not just the individual taking part in the exchange (Bagozzi, 1974). An understanding of motivations, constraints, and behaviors, is integral to developing a social marketing strategy and promoting a favorable exchange. This social marketing strategy involves lessening or removing barriers to the target behavior, while also reducing motivations and perceived benefits to competing behaviors. Likewise, motivations and perceived benefits to target behaviors are simultaneously increased while barriers to competing behaviors are increased (Kotler & Lee, 2007; McKenzie-Mohr, 2011). In this manner, target behaviors become seen as more favorable or desirable, while competing behaviors are viewed as less desirable. The social marketing approach can help to increase initial forest landowner “buy-in” and thus speed the diffusion and adoption of sustainable biofuels production.

The goal for our study is to produce a blueprint social marketing plan to aid outreach and extension efforts in the diffusion and adoption of biofuels technologies and practices by family forest owners. To achieve this goal we conducted key-informant and focus group interviews to:

- (i) Determine the sequence of behaviors or practices (prior through end-state) necessary for family forest owners to produce feedstock for biofuel
- (ii) Determine family forest owner motivations and constraints to feedstock biofuel feedstock production.
- (iii) Assess the impact, probability and penetration of feedstock production practices and behaviors.
- (iv) Discuss how a social marketing plan could use that knowledge to encourage family forest owners to produce feedstock for biofuel.

To address these objectives we conducted one-on-one and focus group interviews with family forest owners and key informants. In this article we present the results of our study and suggest ways that family forest owner motivations and constraints to feedstock production can be incorporated into a social marketing plan.

3. METHODS

3.1 Sampling and Interviewee Recruitment

We conducted both one-on-one key informant interviews and focus group interviews. For key informant interviews, we sought knowledgeable insiders who could help connect us with members of the family forest owner community (Weiss, 1994). We conducted key informant interviews to develop in-depth understanding of current state of biofuel production and technology as well as to help identify knowledge private forest owners would need as well as behaviors and practices they would have to engage in to produce feedstock for biofuels. Through key informant interviews, we acquired formative ideas for use in the design of focus group scripts for later stages of the project. We initially used convenience sampling to recruit key informant interviewees. We recruited those interviewees who were easily obtainable and known in advance and also had knowledge of either wood-based biofuels or family forest owners (Weiss, 1994). From each key informant interview we used the snowball sampling method, where solicited the names of other potential interviewees with knowledge of and experience with biofuels and/or family forest management practices (Weiss, 1994) to obtain recommendations for other potential interviewees. Key informant interviewees working with various aspects of bioenergy included chemical engineers working in biofuel conversion technology, scientists studying alternative ways of growing hybrid poplar with less fertilizer and

water inputs, and hybrid poplar experts. Other key informant interviewees included family forest owners working for forest landowner advocacy and assistance organizations, a researcher with experience working with family forest owners to assess the availability of private forest land for biofuel production, and an expert with the Washington extension service also working with forest owners.

We also conducted seven focus group interviews with family forest owners in Washington State. Focus groups are useful when trying to understand diverse perspectives and look for a range of ideas and to determine what factors influence opinions, behaviors and motivations (Krueger & Casey, 2009). Focus groups also allow for co-construction of knowledge between interviewees where new ideas can emerge from the group. Because focus groups are used to determine the depth of family forest owners' motivations and barriers to the supply of forest residuals as feedstock for biofuels production a random sample of interviewees was not necessary (Krueger & Casey, 2009). We recruited interviewees through a variety of avenues and attempted to maximize diversity of focus group participants to ensure the widest possible range of forest owner views. We used referral and snowball sampling for focus group interviewee recruitment (Morgan, 1998). We also used open solicitation, when necessary, to recruit interviewees by asking those with existing lists and family forest owner contacts to solicit focus group participation.

Selection for hosting focus group sites was based on proprietary maps showing potentially suitable biorefinery locations (Bourque, 2011). It was logical to speak with forest owners who own forest land in these areas, because proximity to a biorefinery will be a limiting factor to feedstock supply capabilities (Mason, 2009). We also considered areas of high forest industry activity in site selection decisions, including areas of potential cellulosic ethanol

facility siting for forest residuals in WA. Additionally, we took into account recommendations made by “expert” key informant interviewees about suitable places to hold focus groups. Four focus groups took place in Western Washington (Grays Harbor, Lewis, King and Skagit Counties) and two took place in Eastern Washington (Spokane and Stevens Counties). Focus Group size ranged from five to nine interviewees with an average of six interviewees per focus group and a total of forty focus group interviewees. Interviewees owned between 5 and 500 acres of land. Of the 40 focus group interviewees, 25 interviewees stated in a pre-focus group survey that they harvested timber for commercial purposes on their property.

3.2 Data Collection Procedures

For both key informant and focus group interviews, the University of Washington’s Institutional Review Board (IRB) reviewed and approved interview procedure before we contacted interviewees [IRB approval numbers 42522; 41068]. We informed interviewees about the nature of the study and attempted to obtain informed consent by having them read and sign two consent forms. Interviewees returned one consent form and kept the other for their records. Both individual and focus group interview conversations were audio recorded and then transcribed using Express Scribe transcription software. We conducted the interviews, transcribed, and analyzed data simultaneously throughout the research project. As a result, we were able to refine interview techniques and continuously incorporate new data and insights.

We conducted nine individual, semi-structured interviews with key informants. Data collection took place from October 2011 through December 2011. Five interviews took place in Washington and two took place in Oregon at sites of the participants’ choosing. Two additional interviews were conducted over the phone. We used a pre-determined list with open ended questions for the interviews. During each interview, interview questions focused on interviewee

knowledge about and experience with bioenergy (including technological innovations and future directions), what knowledge family forest owners would need to have to sustainably produce biofuel feedstock, and potential practices or behaviors family forest owners would have to engage in to sustainably produce feedstock for biofuels. Interviews lasted approximately 45 minutes, ranging, in duration, from 15 minutes to one hour.

We also conducted six focus group interviews with family forest owners. Data collection took place from March through December 2012. We used a pre-determined semi-structured interview guide with open ended questions. Questions solicited information about family forest owner perceived motivations and constraints to producing feedstock for biofuel as well as the impact, probability, and penetration of feedstock production practices. During each focus group interview, interview questions addressed topics including forest owner interest in producing feedstock, benefits and barriers to producing feedstock, and forest owner needs for involvement in producing feedstock. Focus group interviews lasted approximately 2 hours, ranging in duration from an hour and 45 minutes to two hours and 15 minutes.

3.3 Data Analysis

We conducted interviews, transcribed interviews verbatim, and analyzed data simultaneously to refine interview technique and continuously incorporate new data and insights. We used both inductive and deductive methods to analyze qualitative data. We used the NVivo 10 CAQDAS (Computer Assisted Qualitative Data Analysis Software) program for data analysis. For initial analysis of key informant interviews, we used first cycle coding methods, mainly structural coding and In Vivo coding. For structural coding, we placed segments of text to match questions we asked interviewees. We chose structural coding as an

initial coding method to break up the text into categories to facilitate retrieval for later, more in-depth analysis. For In Vivo coding, we coded portions of text verbatim, thus preserving the interviewee's language (Saldana, 2009). We used In Vivo coding as a placeholder for developing codes and themes later on, in attempt to accurately preserve the verbatim expressions of interviewees. We then expanded the list of codes inductively to identify themes and concepts related to feedstock production practices, that emerged from the data and to develop a further refined coding system. We then used the results of key informant interviews to guide the development of focus group scripts.

We also analyzed focus group interviews using both inductive and deductive coding methods. We initially implemented provisional coding as a first cycle coding method, by using a predetermined list of categories for coding (Saldana, 2009). We developed these a priori codes from initial one-on-one interviews with key informants, social marketing literature, and research questions. Our codes and themes were various categories and subcategories of interviewee motivations and constraints towards feedstock production. Codes and themes were also created for the impact, probability and penetration for each feedstock production behaviors or practices. The list of provisional categories and subcategories included both social-psychological and structural-material motivations and constraints for both forest residuals and growing trees for biofuel. We coded interviewee statements In Vivo in an attempt to accurately preserve what interviewees had said (Saldana, 2009) and organized In Vivo codes under the broad social-psychological and structural-material categories. We then expanded this initial list of codes inductively in a reflexive, iterative process to identify key motivations and constraints that emerged from the data and to develop a further refined coding system. Examples of social-psychological codes included “doing the right thing” (motivations) and “ecological concerns”

(constraints). Examples of structural-material codes included “land management benefits” (motivations) and “economic constraints” (constraints).

We also examined and sought to provide a descriptive sense of the likelihood of supplying feedstock (probability), the impact, and penetration of feedstock production practices and behaviors. Our study differs from McKenzie-Mohr’s (2011) framework, since only one possible end-state behavior exists- supplying forest residuals. We chose to adapt the behavior selection model for the purposes of our study by addressing the series of non-divisible prior behaviors, as opposed to the end-state behaviors. We then adapted the meaning of impact, probability and penetration, described as follows: For the purposes of our study, *impact* refers to determining which of the feedstock production practices is most constraining to family forest owners. We identified places where interviewees discussed any behaviors in the series of prior behaviors (e.g. piling debris, loading debris into a truck) it would take to get to the end state behavior (e.g. delivering biomass to a facility) for each of the feedstock production behavior types (growing trees, supplying forest residuals). Of all of the behaviors, one might be more constraining, or impactful, than the others. We identified those constraints that are most frequently discussed by interviewees or that interviewees mentioned would be the most problematic for them, to determine which constraints were the most impactful. *Probability* refers to the likelihood that respondents would participate in feedstock production behaviors if certain feedstock production constraints were removed. We identified places where participants discussed their likelihood of participating in feedstock production practices, given the removal or mitigation of specific constraints. *Penetration* refers to the extent to which family forest owners are already taking part in potential feedstock production or supply practices. We

identified potential feedstock production practices (prior through endstate behaviors) in which interviewees discussed participating.

4. RESULTS

We present a broad overview and general themes of our findings, followed by a description of the series of potential feedstock production behaviors forest owners may have to engage to supply forest residuals for biofuel. We then discuss salient perceived motivations followed by a discussion of perceived constraints. We conclude with a description of the impact, probability and penetration of feedstock production practices. We use quotations for exemplifying motivations and constraints throughout this section.

Skepticism about the viability of a residual-based biofuels industry was a major theme among interviewees. As one interviewee stated, *“I’m just not very optimistic about woody biomass myself (laughs).”* Interviewees were skeptical of the success of a wood-based biofuel industry in general, and believed that even if it were feasible in the future, it was not feasible at present or in the near future. As one interviewee stated: *“Do I think it will happen in my lifetime? Yeah, probably not.”* Interviewees mentioned several potential barriers (both social-psychological and structural-material) to producing and supplying forest residuals as biofuel feedstock as well as several factors that might encourage family forest owners to produce feedstock for biofuels.

4.1 Series of Prior Behaviors Identified for Feedstock Production

Family forest owner interviewees mentioned several practices they might have to engage in to supply residuals. A comprehensive list of behaviors potentially required to supply forest residuals for biofuel is provided in **Table 1**. While focus group interviewees mentioned some of these practices, the list of behaviors was enhanced through key informant interviews as well as informal conversations with loggers and forest owners, who provided more extensive information on the topic than focus group interviewees.

Family forest owner interviewees showed a wide range of knowledge and experience with practices for supplying forest residuals for bioenergy. In some cases, family forest interviewees explicitly discussed individual prior behaviors, but interviewees often described groups of behaviors. For instance, when interviewees referred to “transporting biomass” they were generally referring to several different behaviors at once including piling, chipping, and loading, as well as actually transporting biomass off-site. Some interviewees mentioned that they often hired third parties, such as contractors, loggers, and foresters, to engage in logging practices for them. While some interviewees had logged their own trees, many hired these third parties to do so for them. Nearly all interviewees who logged their own trees had a third party load and transport logs off-site. For each of the practices listed in **Table 1**, forest owners can either engage in the practices themselves or hire a third party to do so for them.

Table 1: Series of potential feedstock production behaviors for forest residuals

Log trees from the forest
Haul whole trees to a processing area (e.g., landing)
Separate branches, limb, and other slash while processing saw logs
Pile forest residuals/slash at landing
Rent a chipper
Purchase a chipper
Use equipment to load woody material and forest residuals into a chipper
Chip forest residuals
Place chips into a chip van or dump truck
Transport chips to biorefinery
Separate pulpwood from saw logs while processing logs
Use machinery to load pulpwood on a truck
Transport pulpwood to a biorefinery
Thin trees from forest by hand (using a chain saw)
Thin trees from forest using a feller-buncher
Use machinery to drag cut trees to the landing
Remove tree limbs with a chainsaw
Use specialized equipment to load logs
Use equipment to remove limbs
Transport thinned trees to a biorefinery

4.2 Motivations to Producing and Supplying Forest Residuals as Biofuel Feedstock

Interviewees identified a variety of salient motivations to producing feedstock for biofuel. Motivations for supplying forest residuals included various land management benefits, economic feasibility and incentives, ecological sustainability, and the potential for small-scale, local infrastructure.

Perceived land management benefits

Interviewees identified a variety of perceived land management benefits from supplying forest residuals for biofuel. Benefits of supplying forest residuals focused on providing an alternative to burning slash piles and a way to improve or upgrade the land. In all of the focus groups, interviewees mentioned that supplying forest residuals for biofuel could provide an alternative to burning slash piles. Interviewees mentioned that a common practice in timber harvesting operations is to accumulate woody debris (slash), such as leftover limbs, tops, and branches, as well as non-marketable timber products, and either leave these materials on the ground or pile the debris. Debris is often piled and burned to reduce the biomass on site, reduce fire hazard, and to aid in replanting efforts. Burning woody debris was not considered ideal by many interviewees as it was seen as costly, time intensive, and wasteful. Some interviewees saw an alternative to burning as such a strong motivator that they expressed a willingness to supply forest residuals even without making money and potentially losing money: These views are highlighted by the following quotes of several interviewees:

We'd love to see a biofuels as solution so we didn't have to burn it, both from a cost of burning as well as the liability and just the time it takes to burn it, and the waste."

I bet you would find it unanimous most landowners would probably even give the stuff away if somebody would come in and take it out and clean up the land...

Even if it wasn't economically feasible, if the biomass was there and...they would buy some stuff from you, even if it cost you more to cut it and haul it up there, you might do that rather than just try to pile it and burn it.

Interviewees also saw supplying forest residuals as a way to improve their land by making it look more aesthetically pleasing, providing an outlet and/or cost

offset for thinning the forest and abating fire hazards, and improving forest health. Interviewees wanted to “do the right thing” but expressed that they needed a market for these materials to make the process economically feasible. The following quotes illustrate the variety of ways interviewees thought supplying residuals could help them improve their land:

...clean up the place and make it look nice and keep it fire safe...

For me personally it's an opportunity to get out some defective trees and thin species I don't like to improve my forest health.

I'd say the big benefit is being able to do a better job managing your land because you can afford to get rid of your residuals.

I think the fire protection was a good point...that's a benefit to a small forest owner is to remove your residuals for fire protection.

Even land that hasn't been logged and hasn't been replanted, there's a lot of junk on it, like vine maple ...even if you could clean all that off and replant it you'd be upgrading your land and doing something with it, if you had a market to do that.

Economic feasibility and incentives

Economic feasibility was important to family forest owners for supplying forest residuals. In general, interviewees were more concerned about the industry being established and viable than making an income or large profit from supplying their residuals. While interviewees saw the major benefits as an alternative to burning and a chance to upgrade their land, many believed that the feasibility of participating was dependent on economic viability of the industry. As one interviewee stated, “*All of us want to do the right thing, we want to improve our land, we want to utilize our products, but [laughs] it's economics.*” While interviewees deliberated economic incentives for supplying forest residuals, they remained skeptical that they could generate a profit from supplying residuals. Economic incentives

included a small economic return, enough money to offset the cost of thinning, and a price equal to or greater than pulp. Some of these scenarios are illustrated by the following quotes:

But you can't get rid of biomass unless there's some kind of incentive there. You've got to have a few dollars that to make it worth your while [to] pile it up and get rid of it.

I'm thinking of my situation ...the early thinning stages where you've got a lot of, small diameter trees they're ... probably not saw logs...but it's related to the pulp price, if I can get above or equal that for biomass I think then you have significant contribution from small land owners.

You don't need much of an incentive, like he says a dollar a ton or something, I mean, better than nothing.

Demonstrated ecological sustainability

While some interviewees focused on the benefits of supplying forest residuals, others wanted assurance that harvesting woody biomass and supplying residuals would be ecologically sustainable. The desire for these assurances was expressed mostly, but not entirely, by those who did not harvest timber for commercial purposes on their properties. These interviewees primarily wanted to know how much woody biomass could be removed from the ground while maintaining the ecological integrity of the forest ecosystem. Secondarily, some interviewees also wanted reassurances that biofuel would be a cleaner fuel than current petroleum products. The following quotes illustrate interviewee need for ecological sustainability as a motivator for supplying forest residuals:

I guess I would be interested and more able to be convinced, and I think most people who value the wildlife habitat or the aesthetic value of their forest, if they could see that taking the stuff out of the forest, not just producing trees that you can chop down but if you're talking about things like slash if that's not going to actually hurt the forest...

So knowing that you're not taking away the forest land soil value ... by doing this-

So if there was a way to show that you're not taking too much out of the soil...

I would feel a lot better about it if I knew that the final product, that energy coming from that biomass, was cleaner than what we have now...

Small-scale and local facilities (decentralized operations)

In five of the six focus groups, interviewees expressed a desire to have small conversion facilities more closely located near small landowners and forest communities. Interviewees saw several benefits of organizing facilities this way, including providing rural jobs: *“If they're going to do fuel conversion with the biomass, siting smaller facilities ... more closely located to the wood products and the forest and more closely located to the people that would get the jobs.”* In focus groups where small-scale, local operations were mentioned, interviewees deliberated over a variety of decentralized options that they felt more positively toward than large, centralized conversion facilities. As one interviewee stated:

“I could see if there were small ... one home or small neighborhood supplementary ... like a single solar panel except you have a generator that you can pop some debris in and if that was plugged into the energy network... putting energy back that way I could see that happening,

This desire for small-scale, decentralized facilities, however, is potentially in conflict with what biofuel “experts” and researchers believe will work for biofuel production, as was expressed by key informants. Some key informants believed that biofuel conversion facilities would be larger, centralized facilities. These types of facilities were viewed as more economically feasible than smaller scale operations and were not seen to fit well with the

dispersed, small acreage forest, common among family forest owners. As one key informant stated:

“...Putting a facility in that would be tailored to small owners would be difficult just because usually the facilities have to be rather large in order to be economic and the small owners are just so dispersed that they have unique challenges that larger owners don’t...”

4.3 Constraints to Producing and Supplying Forest Residuals as Biofuel Feedstock

Interviewees also described a variety of perceived constraints to supplying forest residuals for biofuel. Salient constraints included ecological concerns, perceived lack of economic feasibility and market uncertainty, and conflicts with forest values and management preferences

Ecological concerns

Interviewees expressed ecological concerns related to supplying forest residuals. Ecological concerns were expressed and deliberated more in focus groups where there were fewer forest owners who actively harvested on their property and more participants who owned forest land for amenity purposes rather than timber production. Interviewees indicated concerns about the potential to harm the forest ecosystem by removing woody debris, including soil depletion, habitat diversity reduction, and the potential to alter forest composition. One interviewee expressed her doubt about the sustainability of removing forest residuals from the forest. Another interviewee expressed her concerns for soil depletion and wildlife habitat reduction:

...when it comes down to me and the forest that I live on I think of the loss of the biomass that goes out of the biofuels in the cycle of decomposition, which I’m pretty sure is vital the soil being able to produce more trees so...I’m a little concerned about sustainability...

This is what my fear is. That this is a another layer of removal that's going to deplete the soil resources, habitat for wildlife...and people, if they had the market, they would go after elements of the forest such as down logs, snags, and brush piles, that are really important for wildlife and, as they decay, for the soils, and for habitat diversity for all kinds of creatures that support wildlife. So I fear that it would be like another stripping of the land.

Particular emphasis was placed on the potential ecological impacts if forest residuals for biofuel became a viable industry and use of the materials scaled to a level that would lead to the removal of too much debris. Among the interviewees, there was a wide range of opinions on how much woody biomass is appropriate to remove, ranging from a belief that almost no woody debris should be removed to the belief that almost all could be removed with minimal or no consequences to the forest ecosystem. Those interviewees who were not harvesting timber for commercial purposes and who claimed to own forest land for reasons other than income generation, such as recreation and conservation purposes, deliberated more about ecological concerns than those who harvest timber for commercial purposes. Interviewees also wondered about the environmental impacts of biorefineries and subsequent waste products, as well as the amount of energy it would take to produce biofuel. A few interviewees were also concerned that economic viability of harvesting residual biomass could lead to alteration of the forest ecosystem in favor of smaller diameter trees and more intensive management of forests.

Economic feasibility

Interviewees remained skeptical of the economic feasibility of supplying forest residuals. Interviewees described a variety of factors working together to make supplying forest residuals economically unfeasible. In some instances, interviewees brought up supplying residuals for electricity generation (as opposed to liquid transportation fuel) and related their

economic concerns to knowledge of supplying residuals for electricity generation or firewood. Overall, they remained skeptical that a residual-based biofuels industry could scale up to a viable level and that removing material from the forest could be cost effective. According to one interviewee:

“...economics includes getting it out, after you grow this wonderful stuff maybe somebody can use it, but they couldn't afford to get it out, that's the main problem with it.”

Interviewee reasons for a lack of economic feasibility focused on transportation costs and distance. Factors contributing to these costs included characteristics of family forest land such as small acreages, dispersed properties, and distance to a biofuel conversion facility. As the following quotes show:

“... the scale of the type of cuts that they do in the small acreages is not going to be worth mobilizing the equipment to get that stuff out and personally I'd rather leave it, if it's going to be a push, I would rather leave it on the ground, leave it for the soil. If I'm not going to get a decent price for it I don't want to export it off my land.”

“...how close you are to where it's going to go, because the trucking is so expensive that right now I don't think you could probably travel over 40 or 50 miles in a circle before you'd lose money at it.”

Conflict with forest values and management preferences

It is also important to mention that many family forest owners do not harvest timber or trees in general on their property (Butler, 2008). As one interviewee mentioned, *“...We people in this room we're interested in timberland from our property but I don't know the percentage...of people that own timberland in Washington [that] are probably more interested in the recreation side and never doing anything.”* The focus group interviews were primarily comprised of family forest owners who harvested some trees on their property, though 15 interviewees indicated in the pre-focus group survey that they did not harvest trees for commercial purposes. Some interviewees indicated that they did not remove trees on their

property and had no intention of doing so. By not harvesting trees, these family forest owners are unable to supply residual biomass for biofuel. A few interviewees felt that removing trees would be in conflict with their forest values and reasons for owning forest land, as illustrated by the following quote:

...but forests have so many other values. My husband and I bought this piece of land to protect those other values instead of taking products out. These trees keep tipping over but birds keep nesting on the bottoms of them so that's fulfilling one of the values that we have is going in, looking at this place, watching different kinds of animals use it. It's so little that in grand scheme of things, its destiny is not to produce forest products, it's just too small. Its destiny is to be a green belt and a place that's [not going to] get all cut down up to it I think. And we're both kind of happy about that, that we were able to do this little tiny piece in an urban part of the county...

4.4 Impact, Probability, and Penetration of Feedstock Production Practices

Of all of the prior behaviors required to supply residuals for biofuel, interviewees implied that centralizing and transporting biomass might be the most constraining practices. They primarily expressed concerns about issues related to cost, as a result of distance and smaller, dispersed properties, of transporting biomass off site. Interviewees also raised issues of access in transporting biomass from their forest to a conversion facility. Some interviewees believed that the trucks needed to haul the wood chips, unlike logging trucks, would be unable to maneuver their logging roads. Another interviewee mentioned that her property was too steep to access for logging and biomass removal, while others mentioned that they didn't have the equipment necessary for chipping biomass. As several interviewees stated:

We have to consider cost of transportation...and my question is, the facility that process it, what does it take to develop that. Is it so cost prohibitive that the little meager amount that I would get, because I take my eight truckloads ...there...would it two pay off?

I mean I would love to just go twitch my nose and put it right up there on site and they could use it

You can't afford to move it...so once you talk about moving stuff...that's the hardest thing

...if you're talking 5 acres here and 7 acres there and 10 acres there, the cost of picking up and coagulating this stuff and taking it to a place ...suddenly starts to become very high transportation wise.

The hauler along those log roads isn't as flexible as a log truck

While it was suggested that transporting forest residuals would be the most constraining practices, interviewees expressed their willingness and desire to supply forest residuals if this barrier could be overcome by having someone pick up residuals from their property. As some interviewees stated:

Wouldn't it be nice though if you could do your logging and all your products and then you've got all your debris left and then somebody that's specialized in coming around and cleaning it up.

I'd be happy to haul it to my field and have somebody pick it up and haul it away, free.

I bet you would find it unanimous most landowners would probably even give the stuff away if somebody would come in and take it out and clean up the land

One interviewee even expressed frustration that he could not get a local paper company to pick up his slash piles from his property, *"I tried to give piles of it away to Grays Harbor Paper and they wouldn't even come out and pick it up."*

While interviewees had not supplied residuals for conversion into liquid transportation fuels, they did discuss a variety of potential feedstock production practices in which they had participated. These practices include harvesting trees and generating slash, thinning the forest, supplying pulpwood, piling debris, transporting biomass and hiring contractors to do work on

their property. Again, interviewees implied that transportation of forest residuals off-site had a relatively low penetration. Most interviewees who generated slash either left the debris on the ground, piled it and let it sit, or piled and burned the slash.

5. IMPLICATIONS FOR DIFFUSION ADOPTION

Family forest owners are a diverse group, with widely differing management practices and reasons for owning forest land (Butler, 2008). This diversity of family forest attitudes, values, and beliefs, manifested in motivations and constraints, has implications for how to most effectively tailor educational programs, communicate with, and provide services for family forest owners (Finley & Kittredge, 2006; Kendra & Hull, 2005; Joshi & Mehmood, 2011). Family forest owners also have a wide range of views towards producing feedstock for biofuel. Since family forest owners are so diverse, different persuasive communication strategies and programs will be necessary to encourage them to produce feedstock for biofuel (Kotler & Lee, 2008; McKenzie-Mohr, 2011). In order to create a social marketing plan, heterogeneous groups must be clustered or divided into more homogenous groups based on various characteristics (Kotler & Lee, 2008; McKenzie-Mohr, 2011). In the case of family forest owners, these characteristics could include demographics, land acreage, and forest land values, to name a few. Social marketing plans are then tailored to the barriers, benefits, and competing behaviors of these target audiences. Social marketing plans aim to increase perceived benefits while simultaneously decreasing barriers to engaging in target behaviors. While this study is qualitative and cannot be generalized to the larger population, some trends emerged from the data that can be used to develop a social marketing strategy to encourage family forest owners to supply forest residuals for biofuel.

Persuasive attempts and communication strategies are likely to be successful to the extent that messages match an individual's psychological motivations for holding their particular attitude(s) (Katz, 1960; Wood, 2000; Shavitt & Nelson, 2002). Family forest owner interviewees generally expressed support and had positive attitudes towards supplying forest residuals for biofuel, however support was more widespread among those who actively harvest and manage their forests for timber. Communication and outreach strategies tailored to those who actively harvest timber could highlight perceived land management benefits, including an alternative to burning and a way to improve or upgrade land, in encouraging forest landowners to supply residuals for biofuel. Although interviewees discussed land management benefits in every focus group, these benefits were discussed and deliberated more elaborately by interviewees that were actively managing for timber production on their properties. These interviewees also seemed to identify with the belief that supplying their residuals was "*doing the right thing*" – contributing to the creation of a useful, domestic, fuel product while being better for the environment than burning slash piles. One example of such a messaging tactic that could be used in outreach efforts and materials is: "Don't let a valuable resource go up in smoke! Supply your slash piles for biofuel." This message serves several purposes. It highlights the benefit of the target behavior (supplying residuals for biofuel) while simultaneously decreasing perceived benefits of engaging in the competing behavior (burning slash piles). This message also frames slash piles as a valuable resource, as opposed to a waste product. It is important to mention that some interviewees questioned the practice of piling debris. These interviewees, generally those who do not harvest timber, felt it could be more appropriate to disperse the debris on-site instead of piling. This suggests that highlighting the benefit as an alternative to burning might be more effective for those who are harvesting by appealing to their

utilitarian attitudes toward supplying residuals. However, of those who didn't generate forest residuals themselves, many were still able to see the environmental benefits of other forest owners not having to burn.

Given our findings that interviewees had a wide range of views about how much debris could be removed while maintaining ecological integrity of the forest, efforts may need to be tailored towards changing or altering attitudes and beliefs for those who think removing forest residuals will harm the forest. Greater effort could be put towards communicating with forest landowners with recreation and conservation values about the sustainability of removing forest residuals. Only one interviewee stated that he was against the practice of piling debris and either burning or transporting the material offsite. Other interviewees with concerns over the sustainability of biomass removal expressed their concerns in the form of questions and concerns, but not direct opposition. These interviewees wanted reassurance that woody biomass could be sustainably removed. Family forest owners with these concerns could be provided with information about best management practices for biomass removal. Outreach efforts should communicate how much woody debris can appropriately be removed from the forest without harming the forest ecosystem, using preferred and trusted communication channels (McKenzie-Mohr, 2011). Using trusted sources and communication channels is important to ensure that information is perceived as credible. Since concerns over how much debris can be removed are largely ecological concerns, highlighted benefits might include how supplying forest residuals could make the forest healthier. These benefits include removing diseased trees and making the forest more fire safe by offsetting the costs of thinning. Messaging should also be tailored to match the value-expressive attitudes of forest owners (Katz, 1960; Wood, 2000; Shavitt & Nelson, 2002). For example, harvesting forest residuals has the potential to maintain ecological

integrity and make the forest more aesthetically pleasing. This type of messaging could be more effective for those who are not harvesting timber or who do so on a smaller scale, but it also has the potential to effectively engage those who harvest timber, as many of those interviewees also expressed these types of value-expressive attitudes.

Garnering commitments can be another useful tool for encouraging behavior change (McKenzie-Mohr, 2011), because people generally like to be seen as consistent, and are more likely to follow through with an action to which they have previously committed (Cialdini, 2007). Family forest owners generally have smaller properties and are more diffuse, and may therefore need to aggregate their residual biomass for transportation to a conversion facility to make the process economically feasible. Motivated community leaders could be targeted to encourage neighboring landowners to commit to harvesting trees and supplying biomass at a given time. Descriptive norms could also be incorporated to bolster these commitments (McKenzie-Mohr, 2011). Social norms can be useful to encourage behaviors because people often rely on social proof from those around them to help guide their behavior in a way that others will see as acceptable (Cialdini et al., 1990, Schultz et al., 2007, McKenzie-Mohr, 2011). Descriptive norms demonstrate for people what others are doing. Once one or more forest owners within a community have committed to supply their residuals for bioenergy, persuasive messaging and communication could utilize descriptive norms in conjunction with commitments to encourage buy-in. An example of using descriptive norms would be to include the phrase, either through direct contact or outreach materials, “Many of your neighbors have already committed to supplying their forest residuals for biofuel.” This message communicates to forest owners that others like them are supplying their residuals, and these forest owners may be more willing to commit to supplying biomass themselves.

Removing structural barriers and making it more convenient to engage in feedstock production practices is also an important tool to encourage the supply of forest residuals for biofuel feedstock (McKenzie-Mohr, 2011). Collecting and transporting debris seem to be the most impactful behaviors preventing family forest owners from supplying forest residuals. Resources could be channeled into making it more convenient for family forest owners to supply residuals by having someone coordinate to pick up residuals from their properties. Interviewees expressed that they would be more likely to supply residuals if it were easier and more feasible to transport the biomass. Many interviewees suggested that this would be a motivator, encouraging them to supply residuals for biofuel. Some interviewees also expressed that they hired contractors, loggers, and/or foresters to engage management activities on their properties, instead of doing it themselves. In those cases where forest owners are not harvesting their own trees, efforts could be tailored towards training, educating, and coordinating contractors to pile, process, load, and transport forest residuals. Forest owners could also be provided with information about contractors specializing in biomass removal.

Interviewees believed that in order for residual-based biofuels to be successful, economic feasibility was necessary; however interviewees did not elaborate extensively on making a substantial financial gain as an expectation for participation. While several interviewees wanted to generate some profit from supplying residuals, many interviewees were willing to supply forest residuals at cost or even at a loss, because of the land management benefits of removing the debris from their land. Paula et al (2010) found that income generation was the most significant motivator for forest owner willingness to provide feedstock for biofuel. While motivators explored through this research, such as land management benefits, are in fact indirect economic benefits, it is interesting to note that family forest owner motivations and

constraints are not entirely driven by economics. Interviewees also mentioned non-financial concerns over ecological sustainability and expressed that various environmental benefits were important. Financial incentives and economic benefits are certainly important for family forest owners. However, we suggest that while financial incentives (either directly through profit or indirectly through land management benefits and other avenues) are important, family forest owners are motivated to and constrained from supplying residuals from a diversity of factors besides profit-making.

6. CONCLUSION

The goal of our study was to inform development of a blueprint social marketing plan to aid outreach and extension efforts in the diffusion and adoption of biofuels technologies and practices by family forest owners. We conducted key informant interviews and focus group interviews to explore family forest owner values, attitudes, and beliefs and as they manifest family forest owner motivations and constraints to biofuel feedstock production. We also identified the sequence of behaviors necessary for family forest owners to supply forest residuals for biofuels and provided a descriptive sense of the impact, probability, and penetration of feedstock production practices.

Interviewees identified salient motivations including land management benefits, economic feasibility and incentives, ecological sustainability, and the potential for small-scale, decentralized infrastructure. Salient constraints included ecological concerns, perceived lack of economic feasibility and market uncertainty, and conflicts with forest values and management preferences. The most impactful practices for supplying residuals seemed to be centralizing residual biomass and transporting biomass to a conversion facility. Additionally, few

interviewees had experience transporting biomass off-site. However, interviewees expressed that they were likely to supply residuals for biofuel if it was more convenient and less costly to transport biomass, particularly if someone coordinated to pick up residuals from their property. Based on these research findings, we provided several recommendations for both social-psychological and structural-material interventions to encourage family forest owners to produce feedstock. Several behavior change tools can be utilized to encourage the diffusion and adoption of sustainable biofuels production including targeted messaging and persuasive communication, garnering commitments, and removing structural barriers.

Through this qualitative study we sought to identify the depth of family forest owner attitudes, values, beliefs and knowledge as they influenced motivations and constraints towards participating in a wood-based biofuels industry. While this study contributed to greater meaning and understanding of family forest owners with respect to producing feedstock for biofuel, this study is not generalizable to a wider population. In fact, our sample of forest owners was biased towards those who harvest timber, even though a significant portion of family forest owners do not harvest trees on their properties (Butler, 2008). Future research should survey a generalizable sample of family forest owners in Washington about their motivations and constraints to feedstock production as well as the impact, probability and penetration of feedstock production practices. Market segmentation should be used to determine clusters of forest owners that exist based on management practices, forest values, demographics and motivations and constraints and different social marketing plans should be created targeting individual clusters of landowners.

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APPENDIX A: Key Informant Interview Guide

1. Tell us how long you have been working on bioenergy
2. Do you see any future for that?
3. What kinds of technological advances have been made so far?
4. What other kinds of advances have been made in this area?
5. How can these advances be useful to private family forest owners who are interested in producing feedstock for biofuel?
6. What is your take on the idea that private forest owners in Washington State are capable of sustainable producing feedstock for biofuels?
7. What aspects of that can be “unsustainable?”
8. If you were to advise private forest owners in Washington on the sustainable production of feedstock for biofuels, what will you tell them?
9. What should/can private forest owners in Washington do to ensure sustainable production of feedstock for biofuels?
10. We are hoping to better understand how private forest owners in Washington can sustainably produce feedstock for biofuels production. Is there anything we missed? Is there anything you would like to add before we close?

APPENDIX B: Focus Group Interview Guide

1. Tell us your name and what you like best about your forest land.
2. When you think about biofuels, what comes to mind?
3. What is your take on the idea of family forest owners producing feedstock for biofuel?
4. What do you see as the benefits to you of producing feedstock for biofuel?
5. What kinds of challenges would you face in producing feedstock for biofuel?
6. What would it take to get you to produce feedstock for biofuel?
7. We are hoping to better understand how family forest owners in Washington can be involved in the sustainable production of feedstock for biofuels. Is there anything we missed? Is there anything you would like to add before we close?

APPENDIX C: Human Subjects Review, Key Informant Interviews

Date: June 29, 2011

PI: Dr. Stanley Tanyi Asah
Assistant Professor
Forest Resources

RE: HSD study #41068
“Family Forest Owners and Bioenergy: Anticipating the Diffusion and Adoption of Sustainable Biofuels Production”

Dear Dr. Asah:

The University of Washington Human Subjects Division (HSD) has determined that your research qualifies for exempt status in accordance with the federal regulations under 45 CFR 46.101/ 21 CFR 56.104. Details of this determination are as follows:

Exempt category determination: **2**

Determination period: **6/29/2011 - 6/28/2016.**

Although research that qualifies for exempt status is not governed by federal requirements for research involving human subjects, investigators still have a responsibility to protect the rights and welfare of their subjects, and are expected to conduct their research in accordance with the ethical principles of *Justice, Beneficence* and *Respect for Persons*, as described in the Belmont Report, as well as with state and local institutional policy.

Determination Period: An exempt determination is valid for five years from the date of the determination, as long as the nature of the research activity remains the same. If there is any substantive change to the activity that has determined to be exempt, one that alters the overall design, procedures, or risk/benefit ratio to subjects, the exempt determination will no longer be valid. Exempt determinations expire automatically at the end of the five-year period. If you complete your project before the end of the determination period, it is not necessary to make a formal request that your study be closed. Should you need to continue your research activity beyond the five-year determination period, you will need to submit a new *Exempt Status Request* form for review and determination *prior to implementation*.

Revisions: Only modifications that are deemed “minor” are allowable, in other words, modifications that do not change the nature of the research and therefore do not affect the validity of the exempt determination. **Please refer to the Guidance document for more information about what are considered minor changes.** If changes that are considered to be “substantive” occur to the research, that is, changes that alter the nature of the research and therefore affect the validity of the exempt determination, a new *Exempt Status Request* must be submitted to HSD for review and determination *prior to implementation*.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events or any problem that may increase the risk to the human subjects and change the category of review, notify HSD promptly. Any complaints from subjects pertaining to the risk and benefits of the research must be reported to HSD.

Please use the HSD study number listed above on any forms submitted which relate to this research, or on any correspondence with the HSD office.

Good luck in your research. If we can be of further assistance, please contact us at (206) 543-0098 or via email at hsdinfo@uw.edu. Thank you for your cooperation.

Sincerely,

Laurie E. Berger
Human Subjects Review Coordinator
(206) 543-3033
lberger@u.washington.edu

APPENDIX D: Human Subjects Review, Focus Group Interviews

Date: 3/9/2012

PI: Dr. Stanley Asah
Assistant Professor
School of Environmental & Forestry Sciences

CC: Hanna Lee

RE: HSD study #42522
“Family Forest Owners, Farmers and Bioenergy: Anticipating the Diffusion and Adoption of Sustainable Biofuels Production”

Dear Dr. Asah:

The University of Washington Human Subjects Division (HSD) has determined that your research qualifies for exempt status in accordance with the federal regulations under 45 CFR 46.101/ 21 CFR 56.104. Details of this determination are as follows:

Exempt category determination: **2**

Determination period: **3/9/2012 - 3/8/2017**.

Although research that qualifies for exempt status is not governed by federal requirements for research involving human subjects, investigators still have a responsibility to protect the rights and welfare of their subjects, and are expected to conduct their research in accordance with the ethical principles of *Justice*, *Beneficence* and *Respect for Persons*, as described in the Belmont Report, as well as with state and local institutional policy.

Determination Period: An exempt determination is valid for five years from the date of the determination, as long as the nature of the research activity remains the same. If there is any substantive change to the activity that has determined to be exempt, one that alters the overall design, procedures, or risk/benefit ratio to subjects, the exempt determination will no longer be valid. Exempt determinations expire automatically at the end of the five-year period. If you complete your project before the end of the determination period, it is not necessary to make a formal request that your study be closed. Should you need to continue your research activity beyond the five-year determination period, you will need to submit a new *Exempt Status Request* form for review and determination *prior to implementation*.

Revisions: Only modifications that are deemed “minor” are allowable, in other words, modifications that do not change the nature of the research and therefore do not affect the validity of the exempt determination. **Please refer to the Guidance document for more information about what are considered minor changes.** If changes that are considered to be “substantive” occur to the research, that is, changes that alter the nature of the research and therefore affect the validity of the exempt determination, a new *Exempt Status Request* must be submitted to HSD for review and determination *prior to implementation*.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events or any problem that may increase the risk to the human subjects and change the category of review, notify HSD promptly. Any complaints from subjects pertaining to the risk and benefits of the research must be reported to HSD.

Please use the HSD study number listed above on any forms submitted which relate to this research, or on any correspondence with the HSD office.

Good luck in your research. If we can be of further assistance, please contact us at (206) 543-0098 or via email at hsdinfo@uw.edu. Thank you for your cooperation.

Sincerely,

Bailey Bell
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