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Private landowner intent to supply woody feedstock for bioenergy production

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ABSTRACT

In this research, we evaluated the intent of engaged private forest landowners to supply woody biomass for bioenergy production. The study was conducted in a U.S. state (Kentucky) where private individuals own a majority (78%) of the state's forest resources. Intent of family forest owners was measured using a mail-based survey. We used the Theory of Planned Behavior to model factors that affect landowner intention, and we tested the effect of educational materials on participates' reported intent. Two-thirds of respondents indicated that they intend to include energy wood in future harvests, but the educational material treatment did not affect intentions. Respondents' attitudes, perceived subjective norms, and perceived control each had a significant effect on intent to harvest. No demographic or land ownership characteristics had an effect on behavioral intent. The only prior harvest activity that significantly increased intent was whether the subject had harvested pulpwood from their forest in the past. Respondents identified barriers that may prevent them from harvesting energy wood, providing forestry professionals with a list of challenges to overcome if supply is to be maximized. Lack of bioenergy markets and woodland access issues were the most frequently reported barriers.

1. Introduction

Demand for clean renewable energy sources has increased due to heightened awareness of global climate change and the desire to achieve energy independence from petroleum exporting nations. In response, the U.S. federal government has issued regulations requiring increased use of renewable fuels. The Renewable Fuels Standards (RFS), originally established by the Energy Policy Act of 2005, were updated in 2007 with the passage of the American Security and Independence Act [1]. This standard requires that U.S. states continually increase use of renewable fuels through the year 2025 and limit the amount of corn-based ethanol that can contribute to the total renewable fuel goals. In addition to the RFS, the U.S. Congress has considered the creation of federal Renewable Portfolio Standards (RPS) that would require states to replace a percentage of their electricity usage with energy from renewable sources. RPS mandates or goals have already been adopted by 33 U.S. states [2].

Unlike some regions of the U.S., the Southern U.S. does not possess extensive solar, wind, and/or geothermal resources to offset fossil fuel usage. The relatively lower proportion of the Southern U.S. under row crop production limits agricultural residuals as feedstock for bioenergy production. The Southern

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U.S. does have extensive forest resources (59% of land area) [3] and woody biomass and residuals from the forest products industry will likely serve a keystone role in meeting regional bioenergy feedstock demands. Woody feedstock will most often be collected together with traditional timber products during commercial harvest operations at least until dedicated bioenergy crops, such as short-rotation plantations, are widely established. In this paper, an energy wood harvest will refer to forest harvesting that removes traditional products along with small diameter material appropriate for bioenergy feedstock.

Establishing a woody feedstock supply chain in the Southern U.S. will require participation from family forest owners as they own 59% of the forestland in the South [4]. This is especially true in states like Kentucky where 78% of the forestland belongs to private landowners [5]. A crucial step in determining the availability of feedstocks is to understand whether or not forest landowners intend to harvest energy wood from their property. Estimates of landowner intent and an increased understanding of factors affecting landowner decisions will be valuable for policymakers working to design and implement an effective supply chain strategy, industry professionals planning the construction of conversion facilities, logging companies investing in specialized harvesting equipment, organizations that work with private landowners, and state agencies planning future energy production strategies.

Although the body of literature covering biomass and biofuels is vast and varied, there are still considerable unknowns concerning the supply of woody feedstock from family forests in the U.S., specifically private landowners' intent to participate in harvests that include the extraction of energy wood and the factors that influence those decisions. Recent research has successfully provided willingness predictions and probabilities for some states in the Eastern U.S. along with several key factors influencing those decisions. In a survey of Alabama non-industrial private forest owner's willingness to supply biomass, Paula et al. [6] found significant factors included size of woodland, active management, and price. Additionally, 73% of respondents were willing to supply timber harvest residues for biofuel production. Joshi and Mehmood [7] surveyed family forest owners' willingness to supply biomass in Florida, Arkansas, and Virginia. Significant factors were woodland size, species composition, management objectives, age and education. Most recently, Markowski et al. [8] conducted a similar survey of Massachusetts's family forest owners' willingness to harvest biomass and found a lower probability than the researchers expected and suggested that inter-region results vary. Although these results lay a foundation for understanding the social availability of forest biomass, research should be extended to further understand behavioral factors that influence landowner intent and to evaluate landowner intent within regions that differ in land ownership patterns and forest resource characteristics.

The Theory of Planned Behavior (TPB) is a behavioral model designed to predict human behavior and is a logical extension of the Theory of Reasoned Action [9]. The central idea behind TPB is that intent to perform a specific behavior is the best predictor of future behavior and that intent is a function of an individual's attitude, subjective norms, and perceived behavioral control [10]. Attitude towards the behavior refers to how favorably or unfavorably the individual perceives the action. A subjective norm is defined as the individual's perception of the social pressures to perform or not perform that action and their motivation to comply. Finally, perceived behavioral control represents the individual's perception of how easy or difficult it is to perform the action [11].

There is scientific precedence for designing natural resource surveys using the TPB. Karpinnen [12] used the TPB to model the intentions of family forest owners regarding their choice of forest restoration methods and found that attitude was the strongest predictor of behavioral intent. Munsell et al. [13] used TPB to explore the intent of woodland owners to engage in sustained yield management practices, and Thompson [14] used an expanded TPB model to examine private landowner intent to participate in carbon markets across the United States. Lastly, Pouta and Rekola [15] used the TPB to examine the intent of the community to pay for forest regeneration in Finland while incorporating the use of an experimental information factor to evaluate the effect of previous knowledge on the subjects' intent.

Our primary research objective was to quantify current intent of engaged private forest landowners to include energy wood in future harvests and determine what influences those intentions using a widely accepted theoretical framework of behavioral intent, called the TPB [11]. The second research objective was to test the effect of extension-type outreach information on landowner intent to harvest energy wood. Treatment materials were developed to educate landowners about forest bioenergy production and harvesting. This research used a survey of private forest owners across Kentucky and focused on landowners who exhibited engaged behavior and a degree of interest in forest management. Kentucky is an interesting case study in the U.S. due to its unusually high private ownership of forest resources and its geographical position at the border of the Northern and Southern regions of the Eastern U.S. Kentucky's forests are 78% owned by families [5] compared to 59% in the Southern U.S., 55% in the Northern U.S. and 42% nationwide [4].

The results will strengthen our understanding of family forest owner intent to harvest energy wood in the Southern US. Results of behavioral factors that affect intent to harvest energy wood may apply to family forest owners nationwide. Research findings will also contribute to the current scientific literature by expanding estimates of landowner intent into unexplored populations using cross-disciplinary methods. Additionally, these results will help policymakers and other stakeholders estimate the biomass supply obtainable from private landowners, while planning the future of renewable energy production, and determine what factors affect intent. The work may also provide insight into effective topics and strategies for targeting outreach programs regarding the bioenergy industry.

2. Methods

2.1. *Survey development*

To examine the intent of family forest owners to harvest forest biomass for bioenergy, a self-administered survey consisting of 55 questions was developed. It was designed to