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Social preferences toward energy generation with woody biomass from public forests in Montana, USA

Robert M. Campbell [a,*], Tyron J. Venn [a,b], Nathaniel M. Anderson [c]

[a] University of Montana, College of Forestry and Conservation, 32 Campus Dr., Missoula, MT 59812, USA
[b] University of the Sunshine Coast, School of Business, Sippy Downs, Qld 4556, Australia
[c] U.S. Forest Service, Rocky Mountain Research Station, 800 East Beckwith, Missoula, MT 59801, USA

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A B S T R A C T

In Montana, USA, there are substantial opportunities for mechanized thinning treatments on public forests to reduce the likelihood of severe and damaging wildfires and improve forest health. These treatments produce residues that can be used to generate renewable energy and displace fossil fuels. The choice modeling method is employed to examine the marginal willingness of Montanans' to pay (MWTP) for woody biomass energy produced from treatments in their public forests. The survey instrument elicited social preferences for important co-benefits and costs of woody biomass energy generation in Montana, namely the extent of healthy forests, the number of large wildfires, and local air quality. Positive and statistically significant MWTP is found for woody biomass energy generation, forest health and air quality. MWTP to avoid large wildfires is statistically insignificant. However, MWTP for woody biomass energy diminishes quickly, revealing that Montanans do not support public forestland management that produces more than double the current level of woody biomass harvested for energy generation. These findings can be used by policy makers and public land managers to estimate the social benefits of utilizing residues from public forest restoration or fuel treatment programs to generate energy.

1. Introduction

In 2009, about 83% of energy consumed in the United States came from coal, oil and natural gas (EIA, 2010). In order to reduce greenhouse gas emissions and reliance on imported fossil fuels, the United States government has passed legislation aimed at decreasing fossil fuels use through increased efficiency and increased production of renewable solar, wind, hydroelectric, geothermal and biomass energy (United States Congress, 2005; United States Congress, 2007). About 2% of all energy generated in the United States, representing 24% of renewable energy, presently comes from woody biomass (EIA, 2010), and studies have found that woody biomass could potentially supply up to 10% of US energy needs (Zerbe, 2006). A major barrier to expansion of woody biomass energy in the US has been its high production cost relative to fossil fuels (Gan and Smith, 2006). However, there are significant negative externalities created by the extraction, transport, and combustion of fossil fuels for energy generation (National Academy of Sciences, 2010) and potential positive externalities associated with woody biomass energy that, if accounted for, may make woody biomass energy a socioeconomically efficient component of the energy portfolio in the US.

In order to place a dollar value on the externalities associated with energy generation, nonmarket valuation techniques are required. Nonmarket valuation studies have been used to quantify the value of a wide range of environmental goods and services associated with renewable energy generation, including reduced greenhouse gas emissions (Roe et al., 2001; Longo et al., 2008; Solomon and Johnson, 2009; Susaeta et al., 2011; Solino et al., 2012), improved air quality (Roe et al., 2001; Bergmann et al., 2006), enhanced preservation of landscape quality (Álvarez-Farizo and Hanley, 2002; Bergmann et al., 2006), reduced wildfire risk (Bergmann et al., 2006; Solino et al., 2012) and preservation of wildlife habitat and biodiversity (Álvarez-Farizo and Hanley, 2002; Bergmann et al., 2006). Positive willingness to pay (WTP) has also been found for non-environmental attributes including energy security (Longo et al., 2008; Li et al., 2009) and rural employment (Solino et al., 2012).

Few studies to date have attempted to value externalities associated with woody biomass energy generation specifically. Susaeta et al. (2011) used a choice modeling exercise to assess preferences toward externalities associated with woody biomass energy in Arkansas, Florida, and Virginia. Respondents had positive (but statistically insignificant) WTP for improved forest health, reductions in CO_2 emissions and improvement of forest habitat from reduced wildfire risk. Because

* Corresponding author.
E-mail addresses: robert3.campbell@umontana.edu (R.M. Campbell), tvenn@usc.edu.au (T.J. Venn), nathanielmanderson@fs.fed.us (N.M. Anderson).

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almost 90% of forest lands in the Southern US are privately owned, little of the woody biomass described in the Susaeta et al. (2011) study would come from public lands. In the absence of financial incentives, including markets for carbon, applications of the findings of this study to inform and influence private forest management and woody biomass energy generation appear limited. Solino et al. (2012) found positive WTP in Spain for reduced greenhouse gas emissions, reduced risk of forest fire and reduced pressure on natural resources associated with the utilization of woody biomass for electricity generation.

The US west has unique geographic, ecological, and socioeconomic characteristics - perhaps the most significant of which in this context is the high proportion of public lands compared to other parts of the country. For example, over one-third of the land area of the US state of Montana is owned by the state and federal governments. No past studies have evaluated social preferences regarding woody biomass energy in the western United States, nor have previous studies evaluated preferences specifically toward feedstock generated by forest restoration treatments on public forests. This is an important distinction because optimal decision making with regards to biomass harvesting differs between private landowners and social planners because of differences in private and social accounting of other amenities provided by forests (Hallmann and Amacher, 2014). Additionally, compared to landscapes dominated by private ownership, public preferences are more relevant to, and can be more readily accommodated within, forest management and policy in the western United States.

This study used choice modeling to examine public preferences toward the utilization of woody biomass from public forests for energy generation in Montana. Preferences were characterized in terms of WTP for increases in energy generated with woody biomass harvested from public forests and for potential effects of changes in public forest management on forest health, the prevalence of large wildfires, and air quality. By determining public willingness to trade-off woody biomass energy generation against important environmental attributes, the results of this study can inform public forest management and renewable energy policy in Montana.

The paper proceeds with a description of the geographic and socioeconomic characteristics of the study area, followed by a description of the development of the survey instrument. The econometric model used to analyze the data is presented next, followed by the results of the study, and finally, the study's main findings and implications.

2. Study area and co-benefits and costs of woody biomass energy

Montana's economy has historically relied heavily on agriculture and resource extraction through logging and mining, and the forest industry still accounts for a significant portion of economic activity in several counties in the state (McIver et al., 2013). As has been the trend throughout the rural West, Montana's economy is increasingly service oriented, fueled by tourism and migration based on natural amenities provided by the state's public lands, and recreational opportunities (Rasker and Hansen, 2000). Montana is home to multiple national parks and national forests, which were the main attraction for 11 million of the state's visitors in 2013 (Grau et al., 2014). The state has a large, and expanding wildland-urban interface that allows residents to live among the natural amenities they desire, but also places their lives and homes at risk from wildfires (Rasker, 2014).

Of the 9.4 million ha of forestland in Montana, 3.8 million are classified as moderately or severely departed from natural fire regimes. Forests that are departed from historic fire regimes have increased tree density, structural homogenization, and fuels buildup (Taylor, 2004), resulting from decades of wildfire suppression (Ryan et al., 2013). Forests in these conditions are less able to support native plant and animal species (Huntzinger, 2003; Hiers et al., 2007), are less resilient to disturbances like insect and disease infestation, and more likely to experience unusually severe and damaging wildfires (Schwilk et al., 2009). Forest managers typically mitigate such conditions using mechanized thinning treatments, prescribed wildland fire, or a combination of the two (Rummer et al., 2005). Prescribed fire uses controlled human-ignited fire under favorable weather and fuel conditions to burn excess fuels without igniting the boles and crowns of dominant trees. In contrast, mechanized thinning treatments use heavy equipment to remove and process these fuels, sometimes generating merchantable forest products like sawlogs, pulpwood and woody biomass, which is defined in this context as the limbs, tops, needles, leaves, and other parts of trees and woody plants that are generated as the byproducts of forest management.

Some forestland can be treated with prescribed fire alone, but in cases where very high fuel loads are present, air quality restrictions are in place, or the forest is in close proximity to developed areas, mechanized treatments may be required before, or in place of, prescribed fire (Rummer et al., 2005). Prescribed fire or mechanized forest restoration treatments can increase the area of healthy forests that support a greater diversity of native plant and animal species, and are more resilient to human and natural disturbances like insect outbreaks, non-native invasive species, disease, wildfires and a changing climate (Swanson et al., 1994; Barrett et al., 2012). These treatments can also reduce the severity of large wildfires (Stephens et al., 2009) that can burn homes, damage important municipal watersheds, endanger firefighter and civilian lives, and blanket large areas with wildfire smoke. There is some evidence that, as a result, such treatments result in future fire suppression cost savings, but this effect is difficult to quantify (Thompson and Anderson, 2015).

Woody biomass from timber harvest and fuel treatment is currently used as fuel to generate energy in a number of facilities in Montana, producing 201,000 MW h (MW h) of energy annually (DNRC, 2011; McIver et al., 2013). The majority of this energy is produced by lumber mills that utilize biomass residues created by logging and milling processes to heat and power their facilities, and in one case, to supply electricity to the power grid. Residues from the forest sector are also used to fuel wood heating systems in ten schools and other public buildings throughout the state as part of the United States Department of Agriculture's (USDA) "Fuels for Schools" program. In a case study of one of these wood heating systems, Bergman and Maker (2007) found that the system saved money on fuel costs, with an expected payback period of just under ten years.

Federal legislation like the Healthy Forests Restoration Act of 2003 mandates the federal government to increase the amount of timber harvest and restoration treatment in public forests, and encourages harvesting woody biomass for energy generation (United States House of Representatives, 2003). Mechanized forest restoration treatments typically cut small diameter, subdominant trees with little or no value in traditional timber markets. A woody biomass energy market would provide an outlet for this material and provide revenues to offset the cost of treatments. Additional woody biomass energy generation would also contribute to achieving compliance with the state's renewable energy portfolio standard, which mandates that public utilities and other competitive electricity suppliers serving 50 or more customers obtain at least 15% of their retail electricity from renewable sources as of 2015 (United States Department of Energy, 2015). However, harvesting woody biomass can also have a negative effect on forest health and biodiversity through reduced soil productivity (Thiffault et al., 2011), increasing opportunities for the spread of invasive weeds, and increasing sediment runoff into streams (Shepard, 2006). Additionally, in communities where woody biomass facilities are located, local air quality may be negatively impacted (Chum et al., 2011).

3. Choice modeling survey instrument

Choice modeling is a stated preference non-market valuation technique that allows researchers to estimate the economic values of a set of multiple, divisible attributes, associated with an environmental good. Public preferences toward each attribute are revealed by the