Ecological Economics 145 (2018) 27–37

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Heterogeneity in Preferences for Woody Biomass Energy in the US Mountain West

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

[a] University of Montana, Economics, Liberal Arts Room 407, 32 Campus Dr., Missoula, MT 59812, USA
[b] U.S. Forest Service, Rocky Mountain Research Station, 800 East Beckwith, Missoula, MT 59801, USA
[c] University of the Sunshine Coast, School of Business, Sippy Downs, Qld 4556, Australia

ARTICLE INFO

Keywords:
Biomass energy
Choice modeling
Forest management
Latent class
Public preferences
Willingness to pay

ABSTRACT

Millions of acres of public forest in the US Mountain West are substantially degraded and are in need of restoration. Mechanized restoration treatments can improve forest health and reduce the likelihood of severe wildfire. These treatments produce some timber, and substantial amounts of forest residues that can be used to generate renewable energy and displace fossil fuels. Using the choice modeling method, this study investigates social preferences for generation of energy with woody biomass produced by restoration treatments on public forests in the Mountain West. Both multinomial logit and latent class logit (LCL) models are fit to the data and used to estimate marginal willingness to pay (MWTP) for increased amounts of woody biomass energy generation and important associated co-benefits and costs. Positive and statistically significant MWTP is found for the number of homes powered with wood, the extent of healthy forests, avoiding increases in the number of large wildfires, and local air quality. Significant heterogeneity was found in respondent preferences for the attributes. The heterogeneity can be explained in part by sociodemographic and attitudinal characteristics of respondents. The LCL revealed four classes of respondents with distinct preferences, revealing conflicting viewpoints toward forest management for woody biomass energy generation.

1. Introduction

The United States has passed legislation aimed at reducing greenhouse gas emissions (United States Congress, 2005; United States Congress, 2007; EPA, 2015). In order to achieve the goals set by these commitments, significant amounts of fossil fuel energy will need to be replaced with renewable energy. There are multiple renewable technologies from which to choose, and each option has associated costs and benefits. In order to maximize the social benefits from investments in renewable energy technologies, the external costs and benefits must be quantified and included in the decision making process.

One option for increasing renewable energy production is woody biomass, which can be used to produce electricity, thermal energy, or liquid biofuels. Woody biomass is already used to produce about 2% of the energy in the United States (EIA, 2017) and has the potential to supply up to 10% (Zerbe, 2006). The high cost of production relative to fossil fuels has been a major barrier to expansion of woody biomass energy in the US (Gan and Smith, 2006). However, there are external effects that are not captured in markets and these costs and benefits can affect the socioeconomic efficiency of woody biomass energy relative to other energy options. Because these effects are not captured in markets, nonmarket valuation techniques are needed to quantify the value that society has for them.

Throughout the Western United States there are large areas of public forest that are departed from historic conditions as a result of past management decisions that include wildfire exclusion, poor timber harvesting practices, and over-grazing (Wienk et al., 2004; Hutto, 2008).These overgrown and structurally homogenous forests are less resilient to natural and manmade disturbances, less able to support a variety of native plant and animal communities (Huntzinger, 2003; Hiers et al., 2007), and are more likely to experience unusually severe and damaging wildfires (Schwilk et al., 2009) that can threaten numerous human and ecological values (Graham et al., 2004). Fire-adapted forests that are departed from historic fire regimes are characterized by increased tree density, structural homogenization, and woody fuels buildup (Taylor, 2004). These conditions contribute to high fire severity and are typically mitigated using mechanized thinning treatments, prescribed fire, or a combination of the two (Rummer et al., 2005). Mechanized thinning treatments use heavy equipment to remove excess fuels. They sometimes generate merchantable forest

* Corresponding author at: University of Montana, Economics, Liberal Arts Room 407, 32 Campus Dr., Missoula, MT 59812, USA.
E-mail addresses: robert3.campbell@umontana.edu (R.M. Campbell), tvenn@usc.edu.au (T.J. Venn), nathanielmanderson@fs.fed.us (N.M. Anderson).

http://dx.doi.org/10.1016/j.ecolecon.2017.08.018
Received 7 January 2017; Received in revised form 28 April 2017; Accepted 24 August 2017
Available online 01 September 2017
0921-8009/

Table 1
Summary of stated-preference valuation studies on renewable energy preferences.

Study	Method	Energy type	Location	Key findings
Álvarez-Farizo and Hanley (2002)	CM[a], CR[b]	Wind	Spain	Significant WTP to protect scenic cliffs, fauna & flora and landscapes
Bergmann et al. (2006)	CM	Hydro-power, wind, biomass	Scotland	Significant WTP for landscape quality, air quality, and wildlife diversity
Cicia et al. (2012)	CM	Wind, solar, agricultural biomass, nuclear	Italy	Positive preferences for wind and solar, mixed results for biomass, and negative preferences for nuclear
Ku and Yoo, (2010)	CM	Renewable energy	Korea	Significant WTP to avoid wildfire and air pollution, and to generate employment.
Li et al. (2009)	CVM[c]	Renewable energy	United States	Significant WTP for increase in green energy research and development
Longo et al. (2008)	CM	Renewable energy	England	Significant WTP for energy security, and mitigation of climate change and air pollution
Roe et al. (2001)	CM	Green electricity	United States	Significant WTP to reduce emissions through increases in renewable energy
Scarpa and Willis (2010)	CM	Solar pv, micro-wind, solar thermal, heat pumps, biomass boilers and pellet stoves	UK	Significant WTP for micro-generation renewable energy adoption
Solino et al. (2012)	CM	Forest biomass	Spain	Positive and significant WTP to avoid wildfire, reduce pollution, and reduce pressure on non-renewable resources
Solomon and Johnson (2009)	CVM	Biomass ethanol	United States	Positive WTP for climate change mitigation
Strazzera et al. (2012)	CM	Wind	Spain	Significant heterogeneity in preferences toward the visual impacts of wind farms, explained by respondent attitudes
Susaeta et al. (2011)	CM	Woody biomass	Southeast United States	Positive but insignificant WTP for greenhouse gas emissions reductions, forest attributes (wildfire and pests), and biodiversity protection
Yoo and Ready (2014)	CM	Solar, wind, biomass, other	United States	Significant heterogeneity in preferences for renewable energy, especially solar

[a] Choice modeling.
[b] Contingent rating.
[c] Contingent valuation.

products like sawlogs for lumber, pulpwood for paper, and woody biomass, which consists of the limbs, tops, needles, leaves, and other parts of trees and woody plants that are byproducts of forest management.

Treatment of forestland to improve forest health or reduce wildfire risk produces substantial amounts of woody biomass feedstock that could potentially be used for energy generation. There are however, potential negative effects associated with woody biomass harvest, including potential negative impacts to soils from compaction and erosion and resulting lower site productivity (Thiffault et al., 2011). Additionally, emissions from woody biomass energy facilities may reduce air quality in communities where they are located (Chum et al., 2011). In order to adequately assess the socioeconomic efficiency of any management action that would increase the amount of woody biomass harvested from public forests, public preferences toward the potential outcomes need to be quantified.

The purpose of this paper is to quantify public preferences for an increase in the production of woody biomass energy from public forestland in the Mountain West region, and the potential environmental and socioeconomic outcomes associated with it. Public preferences are quantified in terms of willingness to pay (WTP) using the choice modeling method and econometric modeling techniques that allow sources of preference heterogeneity, which is the degree to which preference structures vary across respondents, to be identified and accounted for. Choice modeling is well suited to this task because it provides the ability to separately quantify preferences toward the multiple different effects associated with an increase in woody biomass energy.

The paper proceeds with a review of studies that have used similar nonmarket valuation methods to analyze preferences toward renewable energy and their findings regarding preference heterogeneity. Next, the methods used to conduct the study are presented, starting with a description of the survey instrument, followed by the econometric models used to analyze the data. Next, the results of the study are presented, and finally, the study's findings and implications for public policy are discussed.

2. Public Preferences for Renewable Energy

Nonmarket valuation has been used to quantify the value of a wide range of nonmarket goods and services associated with renewable energy generation a summary of stated-preference studies is provided in Table 1. Attributes valued in these studies include: 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), preservation of landscapes (Álvarez-Farizo and Hanley, 2002; Bergmann et al., 2006), reduced wildfire risk (Bergmann et al., 2006; Solino et al., 2012), preservation of wildlife habitat and biodiversity (Álvarez-Farizo and Hanley, 2002, Bergmann et al., 2006), energy security (Longo et al., 2008; Li et al., 2009), and rural employment (Solino et al., 2012). Studies of public preferences toward woody biomass energy specifically, have been conducted in Spain (Solino et al., 2012) and the southeastern United States (Susaeta et al., 2010). 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. Susaeta et al. (2010) found positive (but statistically insignificant) WTP for improved forest health, reductions in CO_2 emissions and improvement of forest habitat from reduced wildfire risk. No previous studies have quantified public preferences for woody biomass energy from public lands in the western US, nor have previous studies evaluated preferences specifically toward feedstock generated by forest restoration treatments on public forests. The US west has unique geographic, ecological, and socioeconomic characteristics, including a high proportion of public lands compared to other parts of the country. Not