Forest Policy and Economics 59 (2015) 75–82

Contents lists available at ScienceDirect

Forest Policy and Economics

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

Biomass supply curves for western juniper in Central Oregon, USA, under alternative business models and policy assumptions

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ARTICLE INFO

Article history:
Received 31 October 2014
Received in revised form 1 June 2015
Accepted 5 June 2015
Available online 14 June 2015

Keywords:
Western juniper
Biomass
Supply
Cost
Biofuel
Simulated annealing

ABSTRACT

This study estimates a supply of juniper from private lands to determine how much of the available juniper (*Juniperus occidentalis* Hook) can be economically supplied at alternative prices if a market was to develop for using juniper as a biomass source. While juniper is native to central Oregon, current land management practices have led to a significant increase in its density on much of the landscape. There could be potential benefits related to juniper removal for private landowners, as well as social benefits associated with water and habitat enhancement. At current densities, juniper on these private lands has negative impacts that diminish biodiversity, reduce forage grass and tie up water resources. The difference in the value of cattle productivity resulting from the presence of juniper as well as any forgone net returns from the sale of juniper to the biofuel industry reflects the opportunity cost to the rancher. This opportunity cost does not capture the complete opportunity cost associated with juniper removal since it does not incorporate the enhanced benefits of biodiversity and increased water availability, and thus reflects a lower bound. The supply curves for juniper as a source for biofuel shift in response to profitable harvesting coordination between landowners, the Oregon Biofuel Producer tax credit and increased positive externalities due to juniper removal. Because of restricted road networks the available source of juniper was limited by access — only 27% of the juniper area is on private rangelands, which is the focus of this report. This study identified supply costs under alternative business models and policy assumptions for an aggregate supply of 2.75 million tonnes and illustrated an analytic technique that could be replicated in other areas.

1. Introduction

Native to the United States, western juniper (*Juniperus occidentalis* Hook) has expanded its range in the absence of historically limiting factors. Western juniper forests which span 14 eastern Oregon counties and comprising 1.5 million hectares are the largest source of forest biomass next to the fuel treatment of over-stocked forestlands (Bowyer et al., 2006). A majority of the western juniper woodlands came into existence in the last 130 years and in eastern Oregon, those stands with 10% canopy cover were estimated at 185,000 hectares in 1936 and 0.9 million hectares in 1988 (Miller et al., 2005, Cowlin et al., 1942 and Gedney et al., 1999). Western juniper now covers 3.6 million hectares across Oregon, California, Nevada, and Idaho and is still expanding. This acreage is considered to be predominantly in a transitional state from shrub-steppe to juniper woodlands. Densities of trees in developed woodlands vary greatly from 80 hectare^{-1} trees in dry locations and as much as 1200 trees hectare^{-1} in cool moist sites (Miller et al., 2005). There is also evidence that suggests that the end of the Little Ice Age in Oregon, ending in 1850, has contributed to juniper expansion as a result of warmer and wetter conditions (Miller et al., 2005 and Johnson, 2005). When livestock grazing began in the 1860's fuel loads were reduced and thus reduced the fire severity, but also served to reduce competition to western juniper from grass and shrubs (Burkhardt and Tisdale, 1976).

The expansion of western juniper reduces soil moisture, duration of seasonal stream flows, and ecosystem service production (Deboodt, 2008). Juniper removal can improve range productivity, reduce fire hazard, and enhance wildlife habitat (Miller et al., 2005). Previous attempts to utilize juniper for commercial scale endeavors have been thwarted by its difficulty to harvest and a lack of available markets (McNeel and Swan, 1994). The development of new biofuel technologies could create a reliable and sustained demand for juniper as a feedstock material.

The objective of this study is to estimate the supply curves for juniper, from private lands in Central Oregon, USA. These supply curves provide information on how much juniper would be available at alternative prices if a biomass market was to develop. The difference in the value of cattle productivity resulting from the presence of juniper, as well as any forgone net returns from the sale of juniper to a biofuel industry reflects the opportunity cost to the rancher of not participating in a juniper biomass market. As the opportunity cost rises, due to rising net returns

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http://dx.doi.org/10.1016/j.forpol.2015.06.002
1389-9341/

and/or declining cattle productivity, more acreage (or tonnage) of juniper will be supplied. In addition, this study explores the potential impact of rangeland improvements and other market impacts on these supply relationships.

An economic model is developed to derive the juniper supply curves with and without subsidies under several business models. The resulting discrete optimization problem is solved using simulated annealing. Net returns are dependent upon revenues from the sale of juniper to the biomass market and the costs. Harvesting costs for a likely combination of harvesting, chipping, and truck transport equipment are developed and applied to private forest lands within 64 km of Prineville, Oregon (Fig. 1). The spatial location and inventory volume (dry tonnes) are estimated using Geographic Information Systems (GIS) and remotely sensed data (Fig. 2).

Prineville is the largest city in Crook County, which holds the highest densities of western juniper in Oregon, 2.9 million bone dry tons (Azuma et al., 2005). Prineville was chosen as the center of the study because it serves as a centralized location for biomass collection, with access to railway transportation for the final biofuel product. This location was identified by a company seeking to construct a biofuel facility (Oregon BEST, 2012), because it has abundant biomass feedstock and access to transportation.

The structure of the paper is as follows: the economic model with varying market characteristics is presented to provide a context for the four supply curves, which are captured in the four scenarios. The process used to generate the necessary GIS data is outlined in an ancillary appendix. The formulation of the cost of harvest and transport, followed by a model which captures the ecosystem service production and benefits that would be achieved through juniper removal is provided in the Appendix. The solution method for generating the results for the supply curves for juniper is discussed. Lastly, the results and discussion section point to the key findings and implications of this study, relating the results to ongoing policy discussions concerning biomass, scales of production and the current climate for supporting alternative energy markets.

2. Economic model and solution methods

2.1. Economic model

The supply curves for juniper modeled in this research represent the most likely price/quantity combinations that will be forthcoming from private lands. While the development of a biomass market will lead to innovation, and further development of infrastructure that cannot be

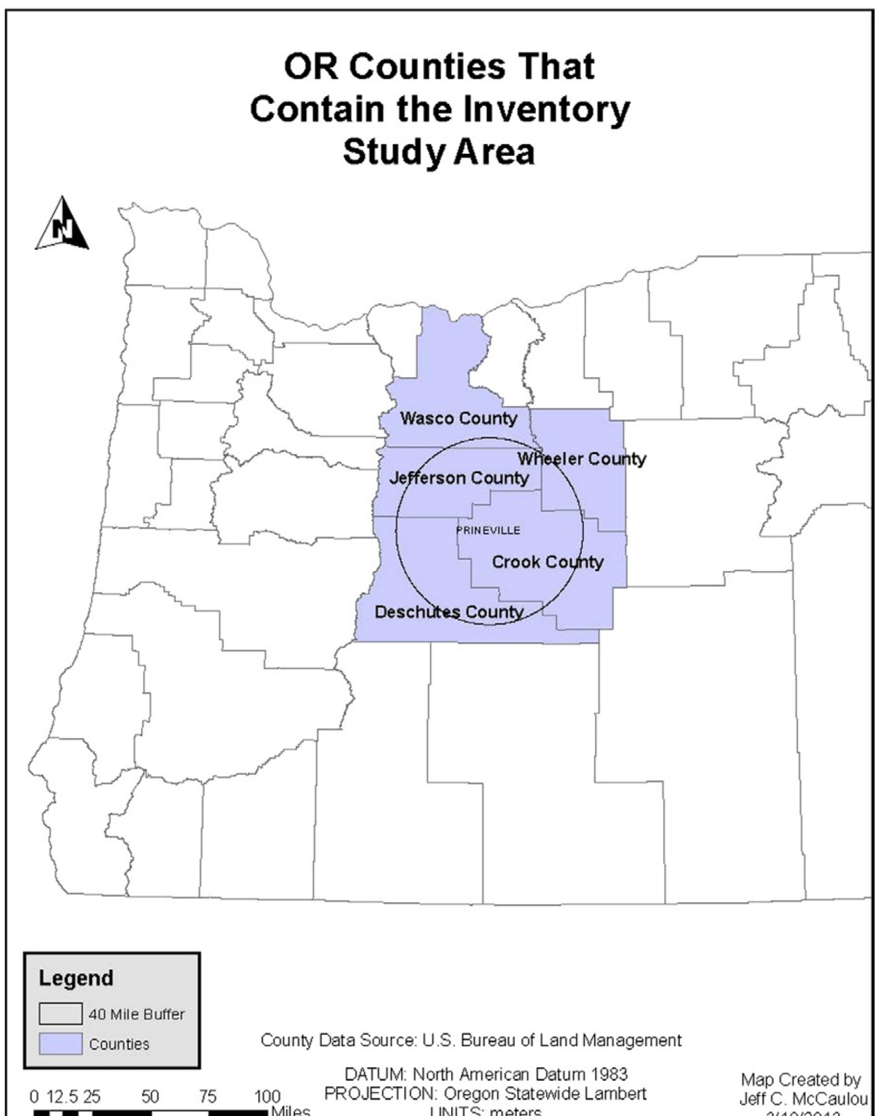

Fig. 1. Oregon counties included in the study.