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The potential rural development impacts of utilizing non-merchantable forest biomass

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ABSTRACT

The development of a market for currently non-merchantable forest material, such as harvest residues or small diameter trees, has been suggested as a possible win-win solution that could: (i) provide a material that can be processed in rural communities reeling from changes in the forest products industry and policy environment; (ii) capture more value from timber management activities; and (iii) provide a financial incentive for treatments to reduce wildfire risk or restore forest stands. Modeling the supply of this material with spatially-explicit potential demand locations allows for a realistic analysis of the feasibility of such a market to stimulate rural development. We model multiple scenarios for the utilization of harvest residues within the current forest products market in western Oregon. Sensitivity analysis explored the effects of cost of the depots on feasibility, including policy designed to support depot establishment through subsidies. Scenarios were also used to assess the effects of increases in federal harvest activities. Results suggest that with relatively high biomass prices, there is some potential for investment in depots to aid rural communities in western Oregon, but there is little change in either the overall feasibility or the location of depot establishment under scenarios of increased federal harvest.

1. Introduction

The forest products industry has been a key component of the economy in the overall Pacific Northwest (PNW) region of the United States, and of its rural communities, for the last century. Lumber and log export are the dominant sources of demand for PNW wood, exposing rural communities with strong ties to the forest resource to macroeconomic cycles in national or global economies (Cox, 1974; Keegan et al., 2011). Roughly half of PNW forestland is owned by federal agencies, making these communities additionally vulnerable to shifts in federal forest policy. From post-World War II to ca. 1990, federal timber comprised over half the total harvest in Oregon. During that period, sustained-yield and other principles of classical forest management were implemented in an attempt to manage rural community outcomes and ease the effects of business cycle fluctuations on mills (Hibbard, 1999; Kennedy et al., 2001; Robbins, 1987).

In the early 1990s, concern about decline of old-growth forests and old-forest-dependent wildlife species led to sharply curtailed federal harvest. Private harvest has dominated the total harvest since then. Both supply shifts (e.g., the decline in harvest on federal forestlands after 1990) and demand shifts (e.g., the housing market crash and great recession that began in 2007) have resulted in closed or reduced mill activity, job losses, and declining socio-economic status in some communities throughout the PNW.

Against this backdrop, there is increasing interest in the development of technologies to utilize biomass, either non-merchantable forest material or material for which no market currently exists, such as pulpwood in some regions. In the PNW, this is primarily non-merchantable residues left following harvest and material that is removed by restoration thinning or wildfire fuel treatment. A market for this material could potentially offer a partial solution to the loss of traditional forestry employment by generating more jobs, including in restoration. Biomass, unlike lumber, could also be utilized locally or for end uses not connected to volatile housing and export markets, thereby diversifying and stabilizing economic conditions for rural communities and businesses.

In this study, we explored the feasibility of market-driven investment in intermediate shipping or processing facilities for woody biomass (which we refer to as "depots") in rural communities in 19 western Oregon counties. In particular, we extended and applied an existing spatially-explicit regional forest products market model (Adams and Latta, 2005) to identify locations where these depots might emerge under a range of price-cost structures and alternative levels of harvest on federal land. It is, to our knowledge, the first attempt to model the use of an emerging forest products technology as a specific rural development strategy within a spatially-explicit, market-driven context. We selected western Oregon because, due to its high levels of forest productivity and profitable harvest, it can potentially supply

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large amounts of biomass as harvest residue and because it contains many forest-located communities that have experienced declining operating mill numbers and employment losses in recent decades. We believe our analysis can provide insight into the potential for using non-traditional forest products to stimulate rural development in forest-dependent communities.

In the next section, we provide an overview of the model developed (a Regional Model of Timber Supply with Emerging Technologies, or RMTSET), including the relationship of this work to previous research, and we describe the model parameters and scenarios. In section three, we describe the results of this application of the model. We close in section four with a discussion of the relevance of our analysis to forest management and policy and the limitations and strengths of our approach.

2. RMTSET, a regional model of timber supply

Assessing the feasibility and implications of biomass utilization is complex. There are many facets to the problem, including: efficient size of biomass processing facilities; optimal locations of facilities with respect to supply of raw material and demand for processed output; amount of biomass available at varying levels of spatial specificity; cost in obtaining the biomass; and potential interactions with larger forest products markets that may in turn drive changes in biomass availability or price. Previous analyses of the potential for biomass utilization have often focused on only one or two of these considerations in order to make the problem tractable.

2.1. Previous research

Forest products sector models have been used to understand and simulate policy scenarios, such as policies affecting trade flows, product mix changes over time, costs associated with longer rotations, and carbon sequestration (Adams et al., 1996; Im et al., 2010; Montgomery et al., 2006). Previous studies using market models to assess the impacts of forest activities likely to generate significant amounts of biomass – typically as a by-product of thinning to reduce wildfire risk – emphasize aggregate demand of existing merchantable products, and do not have the spatial specificity about biomass supply necessary to identify where, in which communities, investment in processing capacity for biomass utilization may occur (Adams and Latta, 2005; Ince et al., 2008; Prestemon et al., 2012, 2008).

Previous models that are spatially explicit about biomass supply are not market models and, hence, do not link biomass production with explicit representations of forest harvest activity that may impact both the price and availability of biomass in the future (Barbour et al., 2008; Daugherty and Fried, 2007). While these studies indicate that harvest residue and restoration thinning may potentially supply sufficient biomass material for power generation in parts of western Oregon, areas of high biomass production and low wildfire risk (e.g., coastal Oregon) were omitted. Models addressing specific locations of biomass processing facilities typically use generalizations of supply, including volumes and prices estimated from one time period, as well as general transportation costs (Jenkins and Sutherland, 2014; Zhang et al., 2011). Assessments of biomass supply that do not account for future growth and yield of the forest resource may overlook critical temporal fluctuations in biomass supply. In addition, these studies ignore feedbacks and impacts within the larger forest products sector. An emerging biomass market may have price impacts that affect forest management and prices in other wood products markets in ways that change the economic availability of biomass that is the desired product. In the absence of emerging demand for biomass, however, development of a biomass market would potentially require subsidies to support the supply side, such as offsetting the establishment costs of depots. Subsidy programs or other policies that support biomass utilization may also have biomass supply implications.

RMTSET extends an existing market model of the forest products industry in western Oregon, adapted to include new sources of both supply of and demand for biomass. In doing so we build on past work examining general biomass supply chains and/or distributed pre-processing center analyses, but with expanded and spatially explicit detail on forest biomass supply (Bowling et al., 2011; Carolan et al., 2007; Noon et al., 1996). RMTSET is uniquely suited for our purpose because it tracks biomass as a separate forest product, models its production within an existing forest products market, and uses spatially-explicit and detailed supply and demand locations. Elements in common with the existing model include use of detailed forest inventory and growth and yield simulations that include biomass; a sawtimber market-driven framework to predict timber harvest and associated feasible biomass supply in a minimally subsidized context; and simulations of market feedbacks that may occur with changes in federal timber harvest and/or removals of biomass.

Similar to Bowling et al. (2011), we develop a mathematical model for placement of distributed preprocessing or shipping centers (referred to as "hubs" by Bowling et al.). In the present work, however, the model is situated in the real-world context of a spatially-explicit set of forest biomass supply sources and rural communities as potential processing locations, all in a landscape of forest management and rural economic development needs. In contrast to previous studies that assessed the economic impacts from an input-output model framework, the spatial nature of our model allowed for consideration of potential economic impacts in specific rural communities (Grebner et al., 2009; Perez-Verdin et al., 2008).

RMTSET combines these features with a model of the biomass market to examine the feasibility of employing new technologies and underutilized material, processed at dispersed locations (depots), to capture some of the benefits of biomass utilization in rural areas. It uses GIS data to identify potential depot locations and to generate realistic transportation cost estimates of biomass from woods to depots and a mixed-integer model that allows spatial tracking of individual biomass facility locations. In the following sections, only adaptations and features unique to the modeling of biomass use and depots are detailed; we refer readers to Adams and Latta (2005) for more information about the base timber harvest model. Key model components unique to RMTSET covered here include:

- Biomass supply, including extraction and transportation costs,
- Potential depot locations and attributes, including establishment and operating costs, and
- The model objective function and constraints.

2.2. Biomass supply

Private log supply to the forest products market is a key determinant of both sawlog price and biomass generation within RMTSET. Current stand conditions were described using Forest Inventory and Analysis (FIA) plot-level data (O'Connell et al., 2015). Projections of future inventory and harvestable material for every modeled management regime were developed with the forest growth simulation model Forest Vegetation Simulator (FVS) (Dixon, 2015). The volume of the bole of the tree from a one-foot stump up to a six-inch diameter top, minus a set percentage allocated to defect and breakage, was designated as sawtimber. The volume (excluding bark) between a six-inch diameter top and a four-inch diameter top was designated as pulpwood. All non-merchantable material typically left on-site is considered biomass, including limbs and the top of the tree. Because on-site biomass is not fully recoverable, proportions of the biomass pool were excluded to represent physical degradation typical in logging and the scattered nature of the material on the site. Potential substitution among products (sawlogs, pulpwood and biomass) was allowed as products initially targeted for