Forest Policy and Economics 69 (2016) 62–72

Contents lists available at ScienceDirect

Forest Policy and Economics

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

Estimates of residual fibre supply and the impacts of new bioenergy capacity from a forest sector transportation model of the Canadian Prairie Provinces

Brian Peter *, Kurt Niquidet

Industry, Trade and Economics, Canadian Forest Service, Natural Resources Canada, 506 West Burnside Road, Victoria, B.C., Canada

ARTICLE INFO

Article history:
Received 19 October 2015
Received in revised form 6 May 2016
Accepted 7 May 2016
Available online 17 May 2016

Keywords:
Forestry
Wood biomass
Bioenergy
Supply chain optimization
Forest sector model

ABSTRACT

Increasing interest in making use of forest sector processing residuals for renewable energy production has led to the need for careful analyses of fibre supply, and the ways in which existing forest sector firms could be affected by new sources of fibre demand. In this paper we present a forest sector transportation model of the three Canadian Prairie Provinces, and use the model to estimate residual fibre production, utilization and surpluses, as well as some potential forest sector impacts from bioenergy capacity additions. Under our base-case assumptions and using 2010 product prices, we estimate that 6.9 million cubic meters (round-wood equivalent) of processing residuals would be traded over the course of a year, with sawmills being the most significant source and pulp and paper mills being the most significant user. Approximately 33% of residuals would be used to produce bioenergy-related products (wood pellets, electricity sold to the grid, or internal electricity and power at pulp mills). Results show that some surpluses of processing residuals may be present in the existing supply chain, though the availability of these residuals is sensitive to lumber prices. At the same time, new bioenergy capacity itself may trigger higher sawmill output, making additional fibre available for both new and existing users. Roadside harvesting residuals are not an economically viable source of fibre under our base-case assumptions; however, their viability is sensitive to roadside processing costs and electricity prices.

1. Introduction

The forest sector is an important contributor to the economies of the Canadian provinces of Alberta (AB), Saskatchewan (SK), and Manitoba (MB). In 2014, the forest sector in these provinces exported a combined $3.52 billion[1] in products while employing approximately 24,000 people. From 2001 to 2013, the average total annual harvest for these provinces was approximately 28.4 million cubic meters (m^3) (CFS, 2016). As with many manufacturing sectors, the transportation of raw materials and intermediate products plays an important role in the profitability of the sector. This is especially true in Canada's forest sector, where fibre may be transported long distances and processing facilities can be far from end-user markets.

Currently, pressure is growing to utilize residual forest sector fibre for a wider variety of products such as bioenergy, in an effort to diversify the forest sector and offset fossil fuel use. However, the carbon implications of bioenergy from forest resources remains a topic of debate, and uncertainty exists around the physical supply of woody feedstock resources for use in expanded bioenergy production (Thiffault, 2013).

In this paper, we present a transportation model that is based on the forest sector of the three Prairie Provinces (AB, SK and MB). The model includes the locations and details of fibre supply regions and processing facilities, and the transportation network linking them. The model is versatile and can be used to explore a variety of issues, such as the potential impacts of investments in processing capacity or transportation infrastructure, forest management activities and policy changes. Particularly through its links to a geographic information system (GIS), the model is a powerful tool for understanding the spatial dynamics of fibre flows within the sector. In this paper, our main objective is to present the structure of the model and our estimates of forest sector biomass supply and utilization in the region, as well as some potential forest sector impacts from bioenergy capacity additions.

Numerous forest sector models have been developed, many of which cover broad geographic areas (multi-national or even global) using price endogenous, partial equilibrium methods (Latta et al., 2013). We instead assume that the sector at the scale we are modelling is a “price taker”, with end-product prices specified exogenously.[2] The model we have developed is essentially a forest sector supply chain optimization model (see D'Amours et al. (2009) for a comprehensive review). These are

* Corresponding author.
E-mail address: bpeter@canada.ca (B. Peter).

[1] All prices, costs and revenues are in Canadian dollars.

[2] Note that Canada's forest sector as a whole is sometimes referred to as a price taker in forest products (Hirsch, 2004; Sadorsky and Henriques, 2001).

http://dx.doi.org/10.1016/j.forpol.2016.05.003
1389-9341/

often concerned with tactical and operational-level improvements, such as making more efficient use of logging trucks (Carlsson and Rönnqvist, 2007), determining the benefits of wood supply exchanges (Frisk et al., 2010), finding the best combination of possible production-distribution modifications (Vila et al., 2006), and the impact of production planning on supply chain costs (Bredström et al., 2004). However, rather than looking for efficiency gains, our objective is to develop a strategic-level tool that can be used to examine the sector-wide implications of changes to prices, costs, processing capacity and fibre supply. We assume the forest sector uses its existing infrastructure in an efficient manner, and that the model will approximate the flow of raw materials, products and co-products likely to be observed in the real world.

The model builds on previous work by Stennes et al. (2010) and Niquidet and Friesen (2014). These models were each developed for a single Canadian province (BC and AB respectively). The BC model (Stennes et al., 2010) is very detailed but is difficult to re-deploy to other regions as a result. The AB model (Niquidet and Friesen, 2014) aimed for a simpler approach and used positive mathematical programming (PMP) to estimate variable delivered log costs. However, its lack of explicit links to timber supply makes it difficult to apply when scenarios involving changes in timber availability need to be examined.

Our objective here is to develop a rigorous, yet practical model that can be easily reconfigured to analyse different jurisdictions and provinces. The model we present covers three provinces, including over 60 processing facilities and 36 timber supply areas. We have chosen a similar structure to the one used in Niquidet and Friesen (2014), but we replace the PMP portion of the model with spatially explicit timber supply and log transportation, which allows delivered log costs to vary based on the actual source of the timber.

1.1. Forest sector transportation in Canada's Prairie Provinces

The forest sector transportation network of Canada's Prairie Provinces is typical of those found throughout the forest sector (D'Amours et al., 2009); it is a large complex system that extends well beyond the borders of the region. It begins in the forest where trees are felled and transported to the roadside with various types of machinery (e.g., feller-bunchers, processors, skidders or forwarders). At the roadside, trees may undergo additional processing (bucking and delimbing) prior to being loaded onto logging trucks, where they are transported to primary processing facilities (e.g., sawmills, pulp and paper mills, plywood mills, oriented strand board mills, or laminated veneer lumber mills). As trees are processed, various co-products such as wood chips, sawdust, planer shavings and residual bark are produced. These may be used internally (e.g., as fuel for lumber kilns), sold for agricultural or landscaping purposes, or may be transported to other forest sector facilities such as pulp and paper mills, medium-density fibre board (MDF) mills, wood pellet manufacturing facilities or bio-energy facilities. Manufactured end-products may be sold and transported to end-users (often via intermediaries), or may be transported to other facilities for further processing (e.g., cabinetry, furniture) prior to reaching final end-users. Finally, once these products have reached the end of their life-span, they may be transported to landfills or in some cases to recycling facilities that could provide an avenue for them to enter the forest sector transportation network once again. Detailed forest sector statistics for each of the three Prairie Provinces can be found in the statistical profiles published on the Canadian Forest Service website (CFS, 2016).

2. The Canadian Prairie Province wood fibre transport model

The model we develop is based on a sub-set of the network described above, which includes wood fibre transport from the forest to primary processing facilities, and co-product transport between facilities (Fig. 1). The model includes 32 lumber mills, 10 pulp and paper mills (producing softwood kraft pulp, hardwood kraft pulp, hardwood mechanical pulp, newsprint or sack-kraft paper), 7 oriented strand board mills, a plywood mill, a medium density fibre board mill, a laminated veneer lumber mill, 3 pellet mills and 4 electricity plants. We have not modelled the transportation of end-products to markets, secondary manufacturing facilities outside the region, or disposal/recycling at the end of product life. The sub-set of the network we model is deemed adequate for the research questions to which we apply the model, although the model could be expanded if needed for future research.

The model seeks to optimize for one year the transport of wood fibre (timber and residual co-products) to available processing facilities so that total sector profit is maximized. Key constraints include the processing capacity of each facility, product and residual co-product recovery factors, harvesting costs, costs to transport logs and co-products, and the annual allowable cut (AAC) of each fibre supply area. The basic structure of the model can be summarized as follows (variable definitions in Table 1):

$$\max Z = TR - TC. \tag{1}$$

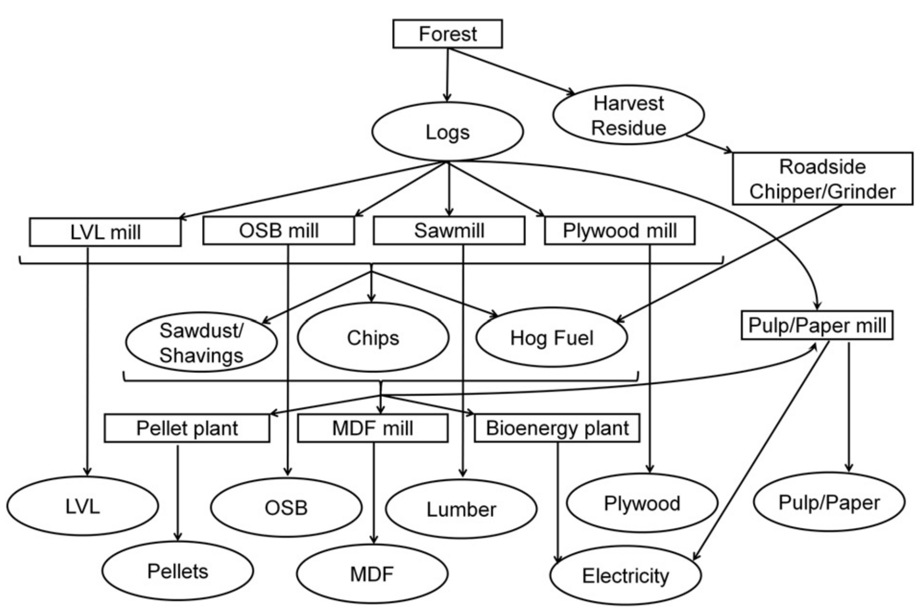

Fig. 1. Structure of the forest sector transportation model of the Canadian Prairie Provinces.