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Essays on the economics of British Columbian timber policy

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Document Version

Publisher's PDF, also known as Version of record

Publication date:

2007

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Niquidet, K. (2007). *Essays on the economics of British Columbian timber policy*. [Thesis fully internal (DIV), University of Groningen]. s.n.

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VI. Using hedonic stumpage models as a management tool in British Columbia

This chapter is based on Niquidet, K. 2007. Using hedonic stumpage models as a management tool in British Columbia. In Review with *The Forestry Chronicle*.

Abstract

In this paper, a hedonic stumpage model is used to assess harvest timing and silviculture investment on a range of sites throughout the interior of British Columbia. It is also used to develop the rent gradient over these lands. Results indicate that much of the bare land in this region is outside of the extensive margin for the purposes of establishing private timber plantations. This may help to explain why, in general, private property rights have developed for existing timber stocks, but not for land. Furthermore, on these marginal lands, rent dissipation as a result of sustained yield management is significantly smaller than lands with higher productivity.

Introduction

The value of standing timber, commonly known as stumpage, is derived from the value of downstream forest products such as logs or lumber. To reflect this, the appraisal of timber was commonly done by a residual value approach. On the surface, the application of the residual value method appears to be a relatively simple accounting exercise, as an appraiser calculates the selling price of the downstream product and subtracts the costs of converting the timber into this product, including some allowance for profit and risk. In practise, such calculations were plagued with complexity. Timber can yield a host of products and grades; as a result its selling price is highly dependent upon the species, size and quality of the timber in question. Equally variable, are the costs of extracting and processing timber, sensitive to several site specific variables.

In many cases the information required for an accurate residual value appraisal was not (widely) known or was costly to acquire. This meant that significant resources were being spent on the appraisal process or accuracy was sacrificed by using broad averages which did not account for individual operating circumstances. In response to the information problems, transaction evidence appraisal (TEA) techniques have become popular (Schuster and Niccolucci 1990). TEA methods simply use data on previous timber sales to assess the likely value of another stand of timber. As discussed above, the sale price of timber will vary substantially according to individual stand specifics which affect either the selling price of the downstream product or the extraction and conversion costs. However, hedonic techniques can be adopted into the TEA framework to explain most of this variation. The great benefit of a hedonic stumpage model, therefore, is their

ability to reveal the impact of marginal timber characteristic changes on stumpage value. These shadow prices create a stumpage equation that allows for quick, accurate appraisal of a wide range of timber stands.

To date these models have been used by forest managers, particularly on public forestland, to set appropriate reservation prices in the auctioning of timber. In an academic setting, hedonic stumpage models have been used extensively to investigate such things as auction design (Hansen 1985), timber sale competition (Brannmann 1996) and the management of biodiversity (Boltz et al. 2002). Nonetheless, in all cases that I am aware of, the hedonic models were applied to assess timber value at a given point in time. As a consequence of biological growth or decay, many of the timber characteristics used in the hedonic model vary through time. Furthermore, these physical characteristics can often be shaped by timber stand improvement activities. All of this suggests that these models could be applied as a management tool in determining the optimum timing of harvest, weighing the costs and benefits of silviculture investments, and in the identification of economic margins for forestland. Using examples from the interior of British Columbia (BC) this paper illustrates how hedonic models can be very useful for these purposes.

The organization of the paper is as follows: in the next section I briefly review the workings of hedonic stumpage models and introduce the model which will be applied in the BC situation. Following this, the next section outlines the methodology taken to 1) calculate the optimum rotation age 2) assess the merits of common silviculture techniques and 3) determine the extensive margin of forestland. This methodology is then applied to BC's dominant commercial tree species, lodgepole pine (*Pinus contorta* Dougl.) across a range of site types. These results are then discussed in relation to current institutional arrangements governing timber use and investment in the province. My conclusions follow.

Hedonic Stumpage Models

The relationship between various timber stand characteristics and its value has been studied extensively. An early study conducted by Guttenberg (1956) however had most of the necessary characteristics. In his study, variables such as volume sold, volume per acre, timber quality, timber species and lumber price all proved to influence stumpage value.

As expected, the significance and sign of these variables are consistent with the residual value method of appraisal: as a result of economies of scale in timber harvesting, larger volumes sold reduce extraction costs leading to higher stumpage values; lower volumes per area have a negative impact on stumpage due to the reduced productivity associated with the need to move equipment more often to extract a unit of roundwood; timber quality, measured by the size and shape of the tree as well as by things like the presence of pest damage, impact stumpage from its influence on both the selling prices of downstream products (e.g. larger straighter trees allowing for more lumber recovery

per unit of roundwood and the production of veneer logs) as well as on processing and extraction costs (e.g. smaller trees with defects caused by decay or pest damage decrease productivity because more felling and bucking needs to be done per unit of roundwood); timber species driving stumpage according to its own intrinsic wood properties (structural or appearance); and finally lumber price (i.e. sawnwood price) shaping stumpage through a derived demand process.

The location of the stand will also be important. Timber is a bulky good that is costly to transport (Yin et al. 2002). Consequently, the distance to the log market is bound to have a significant impact on stumpage. Further, the slope of the land upon which the timber sits will determine the extraction methods employed (e.g. cable vs. ground based) and the productivity of those methods.

Many studies have confirmed the importance of the variables listed above and typical hedonic studies of recent vintage use such timber characteristics as a control to investigate institutional and informational timber sale characteristics. For example, Dunn and Dubois (1999) examined contractual stipulations contained in timber sales, finding that higher performance bonds reduced bids for stumpage and Munn and Rucker (1994) found that information provided by a consultant at a private timber sale could positively increase bids.

Another example of such a study is that of Niquidet and van Kooten (2006). The main purpose of their paper was to investigate the impact of regional competition levels on the bids for standing timber throughout the interior of British Columbia. Their model however, also affirms the associations found by Guttenberg and several other studies. It suggests that the value of a stand of lodgepole pine timber in the southern interior region of the province is equal to the following equation:¹

$$[1] B = 20.136 + 0.287 \text{ LPI} + 0.368 \text{ SLOPE} - 0.011 \text{ SLOPE}^2 - 2.382 \text{ HAUL} + 0.003 \text{ VPH} + 2.109 \text{ LN}(\text{VOL}) + 10.729 \text{ LN}(\text{VPT})$$

Adjusted R² = 0.78, Log-Likelihood ratio = 363.87

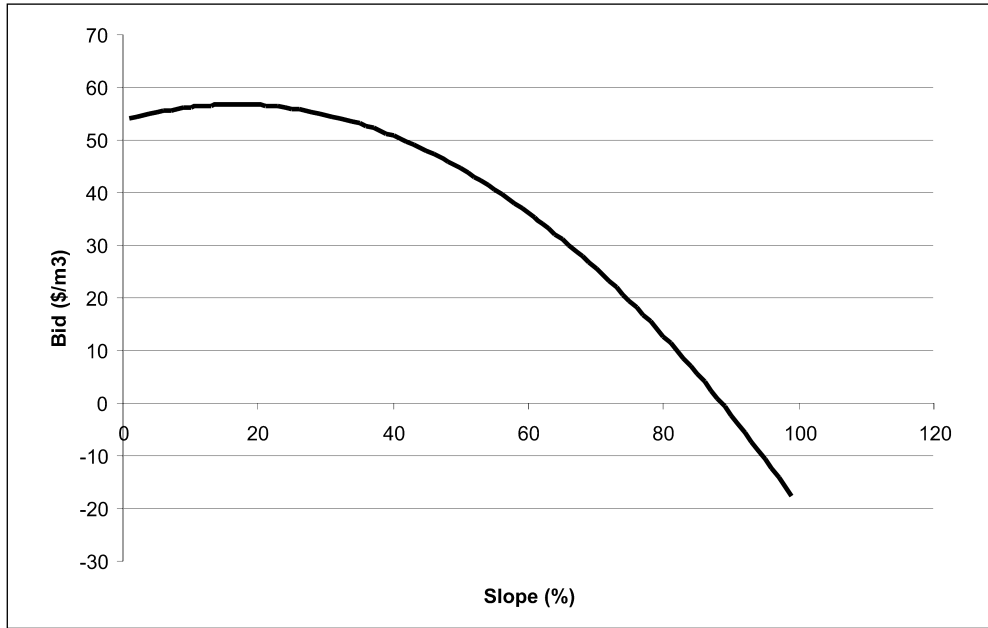
Where B is the bid for stumpage in \$ per m³;² LPI is a lumber price index also in \$ per m³ (found by taking the lumber price at the time of the sale in \$/thousand board feet and multiplying it by the lumber recovery factor (LRF) of the timber stand in thousand board feet/m³); SLOPE is the average slope of the terrain; HAUL is the round trip trucking time in hours to haul logs from the timber sale to the nearest manufacturing center (it also include includes 1 hour for loading and unloading); VPH is the merchantable timber volume per hectare; LN(VOL) is the natural logarithm of the total merchantable volume in the timber sale; and LN(VPT) is the natural logarithm of the net merchantable volume in the stand per tree, also known as “piece size”.

1 Based on reduced form bid equation estimated by truncated regression. Lodgepole pine was a reference species contained in the constant. This equation also assumes that : 1) logging system does not use helicopters or horses; 2) the stand has not incurred fire, beetle or blowdown damage; 3) the road network is already established; and 4) free trade in lumber between the United States and Canada.

2 All dollars in this paper are in 1997 \$CAN

The quadratic relationship between slope and stumpage at first glance may seem a bit puzzling, as over some part of its range slope actually increases bids. This relationship is shown explicitly in figure 1 below, evaluated at the means for the other variables, as reported in Niquidet and van Kooten (2006).

Figure 1. The relationship between slope and the bid for timber in the interior.



This relationship is actually quite logical given the extraction methods currently employed in the interior. Typically, sites in the interior with slopes between zero and forty percent are felled with mechanized equipment and the trees are skidded to a road by wheel based equipment. Loggers attempt to locate roads in a manner where they can, for the most part, skid trees downhill. Having some slope therefore can actually facilitate skidding because it results in less resistance as the trees are dragged over the ground. This probably explains why for the range between zero and seventeen percent bids actually increase with increasing slope. After this point, the steeper slopes start to slow the equipment down as they make their way back up the hill to get more trees, reducing productivity. Productivity then starts to rapidly decline on slopes over forty percent as it becomes too dangerous to use wheel based equipment for skidding and slower moving track based equipment or cable systems must be used. The steeper slopes also increase felling costs as a point is reached where feller bunchers can not safely or productively work on the terrain, meaning labour intensive hand falling with chainsaws will be necessary. Slope however is a static variable.

As a result of biological growth, for a given timber tract VPH, VOL and VPT all change through time. To reflect this, each of these variables along with B should be denoted as being a function of time (t). Exactly how the variables change with t or with

different management activities can usually be readily recovered from a variety of growth and yield models. An example of such a model, that is publicly available, is the BC government's TIPSYS 3.2b program (BC Ministry of Forests and Range 2006). TIPSYS allows users to model growth and yield for a collection of tree species on a range of sites that vary according to their productivity.³ It also will model several stand management regimes such as thinning and fertilization, as well as yield increases associated with using genetically improved seedlings. TIPSYS also contains an algorithm which relates the size and shape of the trees in the stand to their LRF. Combining this with the lumber price, gives the stand's LPI.⁴ Once these variables are established, stumpage can be modelled through time for a site with a given slope and distance to market. Such information could be very valuable for timber supply modelling at both the stand and landscape levels.

Applications

Optimum Rotation

Following Faustmann's original work in 1849 on the optimum rotation in forestry, vast literature has been produced on the subject. Indeed, Newman (2002) documented some 313 published works on the subject. While this literature has proved to be significant, incorporating things like non-market amenities (Hartman 1976), uncertain prices (Norstrom 1975) and stochastic growth (Buongiorno 2001), the basic framework provided by Faustmann has stood the test of time. Faustmann's approach rests on the idea of soil rent, also commonly referred to as the "land expectation value" or "soil expectation value". The soil rent (V) of a hectare of land is simply the net present value of a perpetual harvest of timber every t years. Starting with bare land, the formula for the soil rent of the land is: (Pearse 1990)

$$[2] \quad V(t) = \frac{S(t) - c(1+r)^t}{(1+r)^t - 1}$$

Where $S(t)$ is the stumpage value in dollars per ha at the time of harvest, which in the BC interior case would be equal to $B(t) \times VPH(t)$, c is the cost of establishing trees and r is the discount rate.

The optimum rotation age (t^*) according to Faustmann is that which maximizes the soil rent of the land. Accordingly, the maximum soil rent also identifies the most

3 Technically speaking TIPSYS is not a growth and yield model, it retrieves growth and yield information from a series of tables generated by the growth and yield model TASS (Tree And Stand Simulator). Indeed TIPSYS is an acronym for Table Interpolation Program for Stand Yield. See Lucca 1999 for more details.

4 Consistent with the approach of Faustmann a deterministic price is used in this paper. A mean reverting or random walk stochastic process could be also adopted for lumber price (see for example Brazee and Mendelsohn 1988; Gjolberg and Guttormsen 2002). In principle one could also incorporate stochastic growth and yield (Buongiorno 2001).

one would be willing to pay for the land, something that will be important later in the discussion about the demand for property rights over forestland. Pearse (1990) also shows that the Faustmann rotation age is equivalent to the time where the marginal benefit of delaying the harvest is equal to the cost of waiting. This can be shown as:

$$[3] \quad \frac{S'(t)}{S(t) - c} = \frac{r}{1 - (1 + r)^{-t}}$$

Where the left hand side of the equation represents the percentage growth rate of the value of the current stand and the right hand side reflects the opportunity cost of both capital and land. Thinking of the rotation problem in this way may be more tractable for stands that are already established, as would be the case for much of the forestland in Canada where forests have been put their by nature.⁵

Further characterizing much of the Canadian forest is its low productivity and limited accessibility (Benson 1988). So much so that the opportunity cost of the land, for the purposes of growing timber, in many cases could be zero. This would occur when the soil rent as represented by equation 2, is less than or equal to zero. In that case, the optimum time to harvest an existing stand of timber, assuming basic reforestation was a requirement after harvesting, could be simplified to (Pearse 1990):

$$[4] \quad \frac{S'(t)}{S(t) - c} = r$$

This rotation rule yields what is known as the Fisher rotation, the rotation that maximizes the present value of a single harvest (van Kooten and Folmer 2004).

Given that the opportunity cost of the land for growing timber is zero, the harvest decision is unaffected if rights to only the existing stock of timber are given (and not further rotations). Of course under such a situation there actually would be no incentive for the rights holder (whether they had rights to the stock only or both the stock and the land) to replant and incur c . Without regulation, therefore, equation 4 would not contain c . Nevertheless, in practise, for many jurisdictions, British Columbia included, reforestation is mandatory on the basis of sustainability and non-timber benefits. For some species and sites however, the forest will regenerate naturally in a relatively short time period. In those cases, reforestation regulations could actually be met without incurring c as well.

Silviculture Investment

Establishing trees on bare land is an investment that can be easily assessed by use of equation 2. If the maximum soil rent for growing trees is positive, then planting will occur. Once a stand is established however, further investments can be made to shape the development of the stand and increase its growth and yield. Keeping with the

5 According to the FAO (2000) only 6.8 million ha out of Canada's 245 million ha forest estate could be considered as plantations. <http://www.fao.org/DOCREP/003/X8423E/X8423E00.htm#TopOfPage>

terminology used in British Columbia, in this paper I will refer to stand establishment as “basic” silviculture and additional stand investments as “enhanced” or “intensive” silviculture. Enhanced silviculture could include such activities as pruning, pre-commercial or commercial thinning, as well as fertilization.

To assess the merit of these enhanced silviculture activities one would need to adapt equation 2 to incorporate the cost of the enhance treatment (E) in year y as follows:

$$[5] \quad V(t) = \frac{S(t) - c(1+r)^t - E(1+r)^{t-y}}{(1+r)^t - 1}$$

In spite of the additional cost incurred in year y , the value of the land may increase because the activity will provide benefits at the time of harvesting. These benefits may be the creation of larger tree stems (increased VPT) or simply higher yields (increased VPH). To perform a cost benefit analysis one would therefore compare the value of the land under this enhanced management regime to the value of the land under the basic silviculture regime. If the enhanced management regime increases the value of the land, then it is worthwhile and one would proceed with the activity. If it does not then the basic regime will prevail.

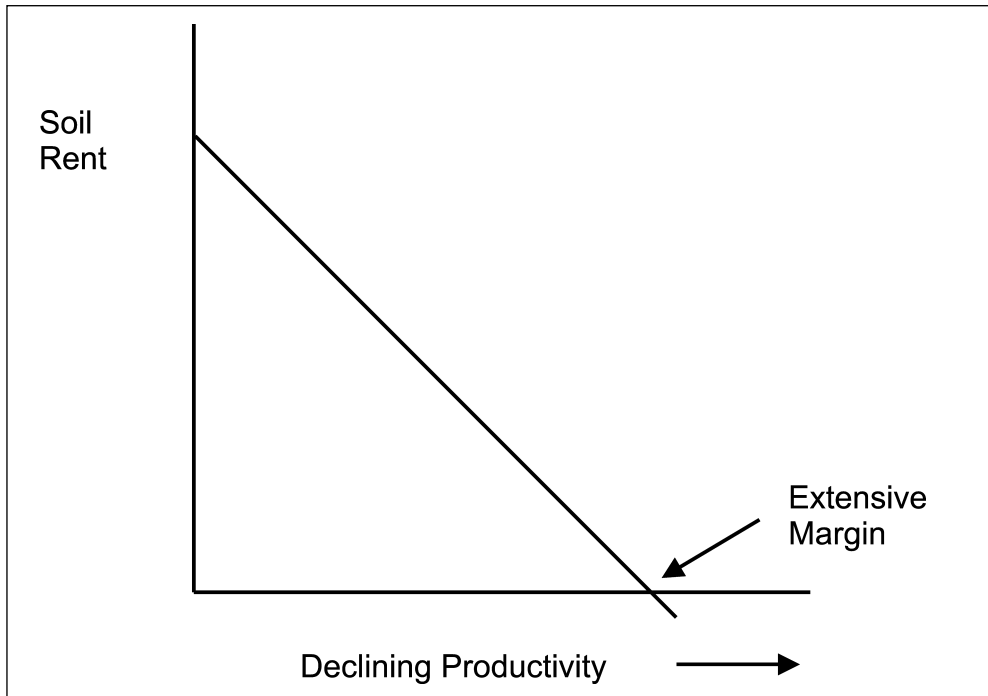
Land Use and Timber Supply Modelling

The soil rent of land for the purposes of growing trees will largely depend on two things. The first being the productivity of the site (Riccardian rent) and the second being the location of the land (von Thunen rent). All else equal, a less productive site will yield lower volumes per hectare and per tree, leading to lower stumpage values and lower soil rent. Therefore, as the productivity of land becomes poorer, eventually a point will be reached where the soil rent becomes zero, a point known as the extensive margin. This is shown in figure 2.

Figure 2 could have also been re-drawn with reference to location, as haul time or slope would replace productivity on the x axis. Finding the extensive margin in these cases simply involves setting the maximum V equal to zero by changing haul time or slope.

When operating commercially in over mature forests - as is the case for virtually the entire interior - the extensive margin takes on a slightly different meaning however. Harvesting this timber earns, what has been termed by Luckert and Bernard (1993), stock rent. This refers to the fact that the stock of timber being harvested has been supplied naturally, without anyone having to incur the cost of establishing the stand or the cost of time. Assuming it is optimum to harvest immediately, the value of this stock rent is simply the stumpage value of the mature timber, which again can be established by equation 1. As a consequence, foresters in British Columbia tend to refer to the extensive margin as the mature stand that earns zero stock rent. This extensive margin can differ greatly from the extensive margin described in figure 2.

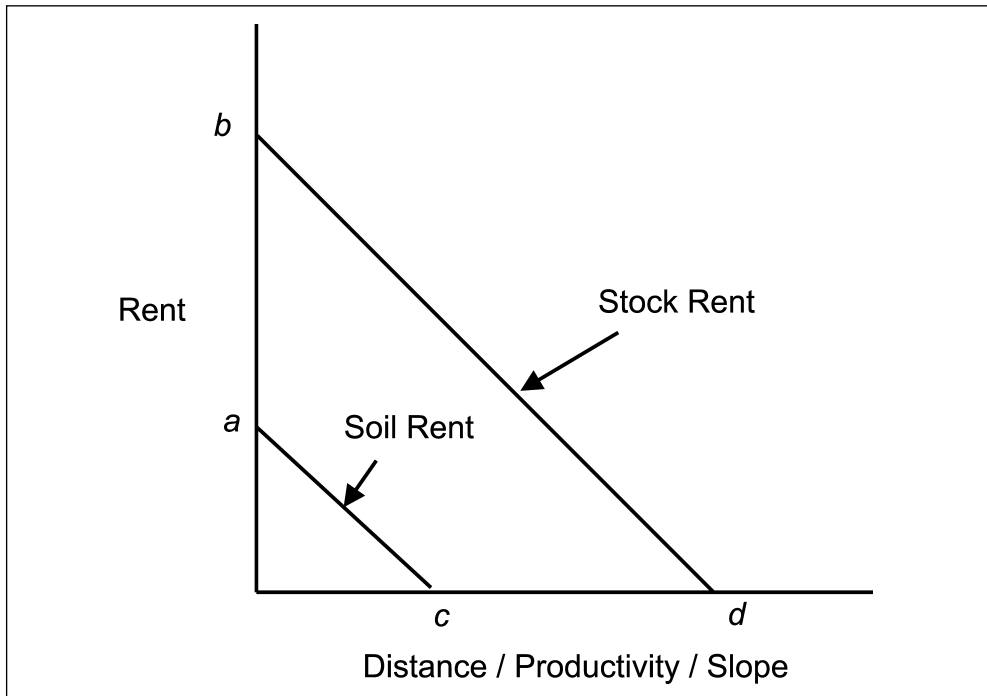
If the land base is blanketed in mature timber, the maximum one will be willing to pay for the land is the sum of the stock rent and the soil rent. It could be the case however, that stock rents are positive on a site, while soil rents are zero or negative. This situation

Figure 2. The extensive margin of forest land.

is shown in figure 3, as in the range between the two extensive margins, point *c* to *d*, the demand for property rights over the land is solely based on the existing stock of timber, not the intrinsic productivity of the land. It is on these sites that one could expect to find property rights for timber but not for land (i.e. timber harvesting concessions or tenures). Furthermore, seeing that there is no private incentive to reforest these sites, other policy instruments will be needed to prevent deforestation, except in cases where natural regeneration is prevalent. In addition, the low stock rents on these sites may not cover the opportunity cost of the non-timber benefits forgone by harvesting, it is on this part of the landscape therefore where sustainability issues and land use conflicts are most likely to occur.

In British Columbia, most of the forest is owned by the public and managed under a regulated sustained yield (SY), even flow harvest regime. This regime entails drawing the stock of mature timber down in a constant manner over a rotation, subject to the growth of the immature stock, in the pursuit of a balanced age class structure (i.e. a normal forest). With SY, timber supply is based almost exclusively on physical criteria as the rotation age used in supply determination is that which maximizes the mean annual increment of the forest. In fact, the only economic input in the process is the identification of *d*, which is termed the timber harvesting land base (THLB) in British Columbia.

Operating under the SY paradigm the chief forester sets the annual allowable cut (AAC) based on an assumed THLB, which is loosely defined by some critical VPH or slope threshold. A study conducted by Williams and Gasson (1986) however has

Figure 3. The extensive margins associated with soil and stock rents.

shown that the THLB can be grossly miscalculated. Although, I would prefer that more economic variables be considered in timber supply analysis, for the purpose of conducting SY timber supply analyses in Canada, employing hedonic stumpage equations could also be very useful. Within GIS and timber supply software, the forested landscape could be divided into operational timber stands (polygons) according to like physical characteristics (age classes etc.) and operational constraints (e.g. maximum harvest unit sizes). Plugging the timber inventory data from each timber stand into the hedonic equation thus would allow one to map a site specific accurate THLB.⁶

Results

Faustmann rotation

Yield information was created from TIPSYS for lodgepole pine planted at 1200 stems per ha on four sites which differed according to their productivity class. These productivity classes are very good (SI_{50} 25), good (SI_{50} 20), medium (SI_{50} 15) and poor (SI_{50} 10). An operational adjustment factor was also applied which reduced yield by

6 This assumes that the timber inventory data is sufficiently detailed to complete the hedonic equation. In discussions with the BC Ministry of Forests and Range, it appears that the current landscape level timber inventory data does not contain all the necessary variables for equation 1.

ten percent to account for anticipated stocking gaps associated with small unproductive micro-sites. For each site, the yield information was then exported to a spreadsheet where stumpage per ha was calculated throughout time by use of equation 1. This calculation was based on a lumber price of \$385 per thousand board feet,⁷ for a logging unit with a slope of 20 percent, 40 ha in size, with a cycle time of 3 hours. Planting costs of \$470.13 per ha were derived for this regime based on a cost function reported in TIPSYS, which is based on BC Ministry of Forests and Range data. Soil rents were then calculated using real discount rates of 3% and 7%, reflecting the likely discount rates employed in forest management by the public and private sectors respectively (Heaps and Pratt 1989). The optimum rotation ages, as well as the corresponding soil rents and some of the timber characteristics at rotation are reported below in table 1.

Table 1. Faustmann management in the BC interior

Productivity	<u>Poor</u>		<u>Medium</u>		<u>Good</u>		<u>Very Good</u>	
	3%	7%	3%	7%	3%	7%	3%	7%
Discount Rate	3%	7%	3%	7%	3%	7%	3%	7%
Faustmann Rotation Age	98	81	67	54	52	42	43	35
Soil Rent (\$/ha)	-276	-463	686	-366	2770	-34	6253	668
VPT at rotation (m ³)	0.12	0.08	0.19	0.13	0.26	0.19	0.35	0.25
VPH at rotation (m ³)	112	78	180	123	250	177	326	238

As expected, the discount rate has a large impact on the timing of harvesting and on the soil rents generated by the land. In fact, only the very good site earns positive soil rents using a private sector discount rate (7%).

Pre-commercial thinning

For this very good site, the feasibility of a pre-commercial thinning enhanced management regime was then analyzed. This management regime has been applied in varying degrees in the past through provincially funded programs such as Forest Renewal BC and through the federal-provincial cost shared Forest Resources Development Agreement, commonly known as FRDA. The stand was thinned down to 600 stems per ha when it reached a top height of 4 meters which corresponded to about age 9. The cost of this treatment being \$ 496.07 per ha, which again was obtained from a cost function provided in TIPSYS, derived earlier from Ministry of Forests and Range data. Results are provided in table 2.

Table 2. Pre-commercial thinning regime on a very good site.

Discount Rate	3%	7%
Faustmann Rotation Age	45	35
Soil Rent (\$/ha)	4758.19	174.65
VPT at rotation (m ³)	0.53	0.35
VPH at rotation (m ³)	271	180

⁷ This price reflects the quarterly average price for spruce/pine lumber in the interior for the period 1996 to 2004.

The optimum rotation age for the thinning regime is 45 years when using a discount rate of 3 percent and 35 years with a discount rate of 7 percent. The thinning proved to increase the size of the trees substantially, as VPT at the time of harvest jumped to 0.53 m³ and 0.35 m³ under the respective discount rate scenarios. This increased the expected bid per cubic metre but also significantly reduced the VPH, having the effect of actually reducing the stumpage per ha at the time of harvest. The reduced harvest value plus the cost of the treatment serves to severely reduce soil rents, falling to \$4758.19 per ha under the 3 percent discount rate scenario and \$174.64 per ha under the 7 percent scenario. Such an investment would clearly be unacceptable from an economic perspective. Given that there are almost limitless potential tree growing regimes (i.e. different initial and post thinning stocking levels) this should not be taken to suggest that there is no role for pre-commercial thinning in British Columbia. It does however illustrate that the hedonic method can be easily used by forest managers to assess the tradeoffs associated with the several potential regimes.

Extensive margins

The results listed in table 1 are for a site with a round trip haul time of 3 hours, which in a Canadian context is relatively close to the log market. The extensive margin of these sites was then calculated by setting the maximum soil rent equal to zero by changing the haul time; this was carried out by the solver tool in Microsoft Excel. The results, listed in table 3, suggest that the private market using a discount rate of 7% would not establish trees on any poor to medium sites regardless of their proximity to the market and would only demand bare land for forestry purposes on good sites within 1.71 hours of the market and on very good sites 14.9 hours from the market. This appears to be a very small part of the interior forest estate as according to British Columbia Ministry of Forests and Range data, shown in table 4, only about 12% of the interior THLB can be considered good or better (most of which is concentrated in the Southeast region).⁸ This also contrasts significantly with the state operating under a public sector discount rate of 3%. Under this scenario it is still not worth it to establish trees on poor sites but tree growing on medium, good and very good sites are viable on a vast stretch of land.

Table 3. The extensive margin for different classes of land in the BC interior

Productivity	<u>Poor</u>		<u>Medium</u>		<u>Good</u>		<u>Very Good</u>	
	3%	7%	3%	7%	3%	7%	3%	7%
Discount Rate	3%	7%	3%	7%	3%	7%	3%	7%
Extensive Margin (hours)	-	-	13.60	-	22.00	1.71	28.00	14.90

8 Perhaps not surprisingly the Southeast contains the only significant parcels of private timberland in the interior. Comparable data was not available for the Fort Nelson and Peace Forest Districts (both located in Northeast BC) so they were excluded from the Northern Interior.

Table 4. The productivity of the BC interior timber harvesting landbase

Site Index (breast height age 50)	Northern Interior ^a (hectares)	Central Interior ^b (hectares)	Southwest Interior ^c (hectares)	Southeast Interior ^d (hectares)	Total (hectares)
< 15 m	3,255,921	2,129,620	1,231,879	165,000	6,782,420
15 - 20 m	3,583,485	1,336,975	2,248,188	433,139	7,601,787
> 20 m	461,296	189,898	275,202	1,071,401	1,997,797
Total	7,300,701	3,656,493	3,755,269	1,669,540	16,382,004

^a Includes all of the Northern Interior Forest Region except the Peace and Ft. Nelson Forest Districts

^b Includes the Quesnel, Chilcotin, Central Cariboo and 100 Mile Forest Districts

^c Includes the Columbia, Okanagan, Kamloops, Cascades and Headwaters Forest Districts

^d Includes the Rocky Mountain, Arrow-Boundary and Kootenay Lake Forest Districts

Now consider the same land base but naturally stocked with mature timber, 300 m³ per ha, with a VPT of 0.5 m³, and a LRF of 250 board feet per m³, roughly the average stand currently being harvested in the BC interior. Unlike the rents for the soil, this stock rent is considerable and the demand for it extends far across the landscape, as the extensive margin in this case is 28.6 hours away from the market centre.

Discussion

Property rights and Silviculture

The results in this paper seem to call into question the empirical findings of previous studies which showed that greater silviculture expenditure in British Columbia will occur on private land where owners can reap the reward of their investment (Luckert and Haley 1990; Zhang and Pearse 1996). What might explain this contradiction?

It is difficult to say for sure without further research. However, I would suggest it could be due to two reasons. Firstly, in both instances the private land surveyed was part of a management unit managed under SY.⁹ As a result, higher expenditures could be the result of the allowable cut effect where silviculture is undertaken simply because it lessens the constraints put in place by SY on how quickly the stock of mature timber can be liquidated (Schweitzer et al. 1972; van Kooten and Folmer 2004). Put another way, silviculture is taking place on the basis of stock rents not soil rents. This differs from the analysis in this study where the stand alone benefits of silviculture were assessed. It is not clear if such expenditure would be undertaken if the investment had to hold up on its own.

Secondly, and probably more importantly, is the location and productivity of the private land sampled by these studies. Private forestland in British Columbia exists

9 In the case of Luckert and Haley (1990) the private land was a 'Taxation Tree Farm' where the owner committed to SY. This land often was also part of a larger public management unit called a Tree Farm License managed collectively under SY. In the case of Zhang and Pearse (1996) all of the private land was part of a Tree Farm License managed by SY.

primarily on the east side of Vancouver Island. This land is relatively flat compared to other parts of the coast, is close to processing facilities and offers growth rates that do not exist in the rest of Canada. While Zhang and Pearse's model does attempt to control for location and site quality, they do not appear to have adequately sampled private lands. For their sample statistics (table 3 in their article) reveal that virtually no private land was included outside of the coastal forest region.¹⁰ Of course this is probably an artefact of the data which was available to them, as few larger industrial private forestland holdings exist in the interior.

Ultimately then, this raises the possibility outlined by Bromley (1991), that property rights have been endogenously determined, explained by the "inherent nature of the land, through the rent gradient". By failing to recognize this endogeneity however, these studies are potentially subject to Bromley's critique; erroneously suggesting that causality runs the other way, with the property rights regime explaining the rent and investment in the land. While their results may hold true for forestland on the coast in a similar location with comparable productivity, this study suggests they should not be broadly applied across the interior of the province as, for the most part, the private sector would not establish trees at all. Furthermore, given that the productivity of the forested estate in the rest of the country is more akin to the interior, one should be cautious about transferring their results to other parts of Canada, particularly the slow growing boreal forest which dominates Canada's North.

Existing institutions and institutional change

The above results therefore also seem to shed some light on the existing timber institutions in British Columbia and probably the rest of Canada, where over ninety percent of the land is publicly owned and rights to harvest mature stocks of standing timber are granted to private companies. This is not to say that existing institutions are efficient, rather than managing the forest under Faustmann's rule, the provinces regulate timber harvests according to SY policies which as mentioned earlier entails drawing the existing stock of mature timber down in a constant manner over a rotation and harvesting immature stocks once they reach the age that maximizes mean annual increment.

Alston et al. (1996) suggest that demand for institutional change comes from the difference between the potential rents generated under a competing regime with that of the status quo. Seeing that the SY policy effectively involves two policy choices (how quickly to liquidate existing over mature stocks and what rotation age to manage new crops) which involve stock and soil rents respectively, in analyzing rent differentials and the demand for change, it will be useful to distinguish between the two.

In terms of the former - the liquidation of the mature stocks - establishing an alternate policy or property rights regime in which to compare to SY will be complicated by at

¹⁰ 98% of the private land sampled was from the coast.

least three things. First, seeing that British Columbia can be considered a large player in the North American timber market, where demand has been shown to be inelastic (van Kooten 2002), alternate rates of harvest will likely have price effects. Indeed, a potential advantage of public ownership that is frequently not mentioned is that it affords the province the ability to set harvest quotas with reference to their impact on North American lumber prices (*Ibid*). Secondly, some of the existing mature timber may contain traits which are not available from second growth stands, as such this timber can be thought of as a non-renewable resource, generating scarcity rent as it is depleted.¹¹ Lastly, several non-market amenities can be attributed to the mature stock. Any rent dissipation could be justified on the basis of providing these non-timber products. Such a complex analysis is well beyond the scope of this paper.

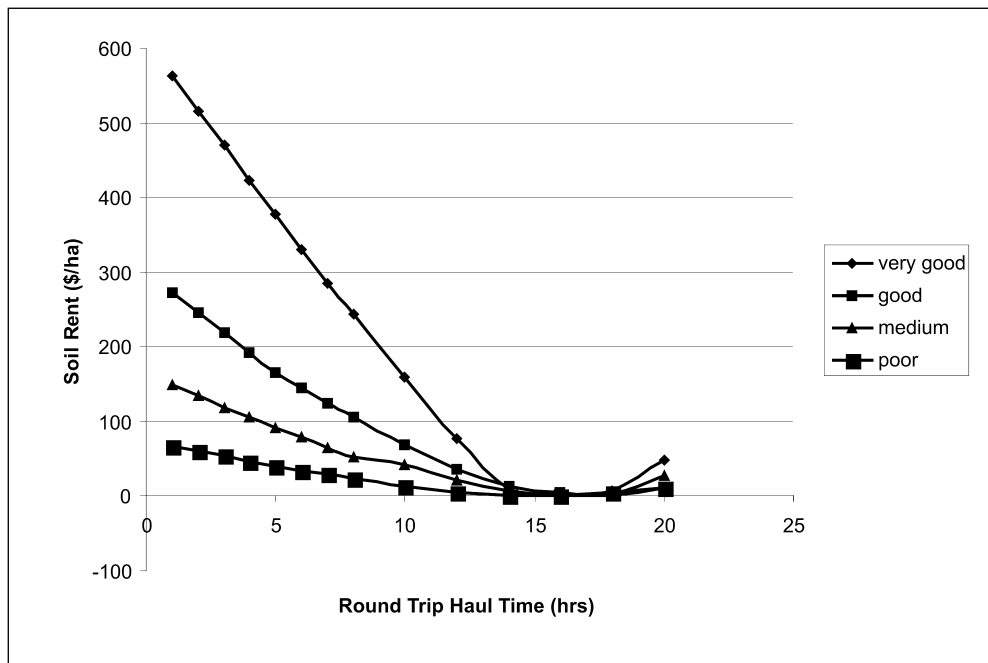
In terms of the latter, it is trivial to suggest that SY dissipates rents as by definition the Faustmann rotation age maximizes soil rent. However, in the BC interior case, on lower quality sites further from the market centre, the demand for institutional change may not be all that great. Figure 4 shows the rent dissipation associated with SY for the different classes of land defined earlier as distance to market increases.

As the productivity of the land increases or the distance to market centre decreases, the amount of soil rent that the SY policy dissipates increases. As a consequence one can expect that pressure for change will be largest on the very good sites close to processing facilities. The demand for change on lands that are not very productive and further from the market centre may not be enough to break from the status quo however. Particularly once one considers the non-timber benefits which are produced from the longer SY rotation.¹² For instance, van Kooten et al. (1995) found that if one considers the role forests play in carbon sequestration, rotation ages would typically be slightly longer than the Faustmann age. Growing timber on a longer rotation is also frequently beneficial to several species of wildlife and older stands are generally preferred for recreational purposes. These values are often hard to quantify however. For practical purposes though, the SY rule may be suitable and even relatively more efficient than Faustmann management on much of the poor and medium sites and on good and very good sites far from the market.

In summary, outright privatization of either the land or the stock of mature timber will not necessarily be more efficient. Institutional reform, which grants the private sector greater control over these resources, must be cognizant of the incentives the private sector faces. On land that is highly productive such that the private sector has the incentive

11 This will depend on the species in question, its age and the availability of substitute products. Given the history of fire disturbance much of the mature stock in the BC interior is between 80 to 140 years old. The timber coming from such stands, particularly pine and spruce, can hardly be seen as being non-renewable as they are still relatively small in size and are typically used to produce products (framing lumber and pulp) which can be made readily from second growth stands. In contrast, timber in “wet belt” regions that have not been exposed as frequently to disturbance may be very old (>300 years). The large stems in these stands are much more likely to exhibit characteristics (fine grain) which are non-renewable, particularly for species such as Douglas fir and western red cedar.

12 The Faustmann and SY rotation ages tend to converge at around 16 hours from the market centre, after this point the Faustmann age is actually longer than SY. However, since there are several market centers spread across the interior landscape, most land is within 10 hours of any given market centre.

Figure 4 Soil rent dissipation under SY management with 3% discount rate

to invest back into the land, then these incentives may well be consistent with public objectives and institutions need to be designed to reflect this. This will probably entail establishing stronger property rights to the land (tenures with lengthened durations or outright privatization). However, due to the low productivity of most of the land, it appears that reforestation on much of the British Columbian interior landscape is a cost that the private sector will not incur on its own. As a consequence, maintaining public ownership of the land with tenure arrangements based on the harvesting of mature timber and regulations governing basic reforestation may be entirely appropriate. Furthermore, on these marginal lands, management by SY, after one considers various non-timber benefits, for practical purposes may be completely suitable.

Conclusion

This paper presented an alternate use for hedonic stumpage models. It showed that they can be simple and flexible in the valuation of timber throughout time. Further, because they take into consideration site specific attributes of the timber and the land, they have the potential to be very powerful and accurate. Consequently, they can be a very useful tool for a host of decisions facing forest managers. This includes decisions pertaining to the timing of harvesting, the benefits of silviculture investments and the identification of the extensive margin.

It was also shown that such assessments can also be an important input in institutional

design and forest policy formulation. In the case of British Columbia's timber institutions they were able to reveal the rent gradient over forestland throughout the interior and how that has likely contributed to the lack of private forestland in this region and perhaps the rest of Canada. They also revealed the flaws associated with existing policy based on one sized fits all SY management. The challenge, as it has always been, will be to design timber institutions in the province in a manner where private incentives match those of the public. To that end it is important to understand the incentives facing the private sector on different parts of the landscape and to design policy instruments accordingly. This applies to the management of existing stocks of timber as well as the land.

References

- Alston, L.J., T. Eggertsson, and D.C. North. 1996. *Empirical Studies in institutional Change*. Cambridge University Press.
- Benson, C.A. 1988. A need for extensive management. *For. Chron.* 64: 421-430.
- Boltz, F., D.R. Carter and M.G. Jacobsen. 2002. Shadow pricing diversity in U.S. national forests. *Journal of Forest Economics* 8(3): 185-197
- Brannman, L.E. 1996. Potential competition and possible collusion in Forest Service timber auctions. *Econ. Inq.* 34: 730-745.
- Braze, R. and R. Mendelsohn. 1988. Timber harvesting with fluctuating prices. *For. Sci.* 34: 359-372.
- Bromley, D.W. 1991. Property rights regimes: formation and policy issues. In *Environment and the Economy: Property Rights and Public Policy*. Blackwell, pp. 136-49.
- Buongiorno, J. 2001. Generalization of Faustmann's formula for stochastic forest growth and prices with Markov decision process models. *For. Sci.* 47(4):466-474.
- British Columbia Ministry of Forests and Range. 2006. Topsy version 3.2b [online]. Available from <http://www.for.gov.bc.ca/hre/gymodels/TIPSY/new.htm> [accessed 6 September 2006].
- Dunn, M.A., and M.R. Dubois. 1999. Determining econometric relationships between timber sale notice provisions and high bids received on timber offering from the Alabama Department of Conservation/State Lands Division. In: *Proceedings of the 1999 Southern Forest Economics Workshop*, Biloxi, Mississippi, April 18-20, 1999.
- Guttenberg, S. 1956. Influence of timber characteristics upon stumpage prices. Occasional paper 146 New Orleans: USDA Forest Service, Southern Forest Experiment Station.
- Hansen, R.G. 1985. Empirical testing of auction theory. *Am. Econ. Rev.* 75: 156-159.
- Hartman, R. 1976. The harvesting decision when a standing forest has value. *Economic Inquiry*. 14:52-58.
- Heaps, T., and B. Pratt. 1989. The social discount rate for silviculture investments. B.C. Ministry of Forests and Forestry Canada, Victoria, B.C. FRDA Rep. 071
- Luckert, M.K. and J.T. Bernard. 1993. What is the Value of Standing Timber?: Difficulties in Merging Theory with Reality. *For. Chron.* 69(6): 680-685.
- Luckert, M.K. and D. Haley. 1990. The implications of various silvicultural funding arrangements for privately managed public forest land in Canada. *New Forest* 4:1-12.
- Munn, I.A. and R.R. Rucker. 1994. The value of information services in a market for factors of production with multiple attributes: The role of consultants in private timber sales. *For. Sci.* 40(3):474-96.
- Newman, D.H. 2002. Forestry's golden rule and the development of the optimum forest rotation literature. *Journal of Forest Economics*. 8(1):5-27.

