Opportunity Costs of Rules Defining the Timber Harvesting Landbase and Harvesting Order

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Summary

The size of the landbase upon which timber harvesting may occur and the order in which forest stands are harvested on that landbase are critical factors that profoundly affect the economic benefits derived from the forest.

Recently in British Columbia, two guidelines have been proposed that constrain both the extent of the landbase and the order of harvesting. The landbase upon which the allowable annual cut (AAC) is determined may be restricted to lands where operability is confirmed through past or present performance, and harvesting within the landbase may be required to be distributed proportionately across all forest sites and types. The latter policy is popularly known as harvesting the profile of the forest.

This paper examines the opportunity costs of these policies with respect to timber supply and net revenue from harvesting for coastal British Columbia.

In this study, the average price of logs traded on the Vancouver Log Market is used to identify components of the timber harvesting landbase. Those lands that were continually economically operable during the last market cycle constitute the primary landbase, and those lands that became operable during the market cycle as prices rose above the cyclical minimum are the opportunity landbase. The primary plus opportunity landbase as defined by the most recent market cycle is the short-term landbase; price trends extending over multiple market cycles may expand this landbase into the long-term landbase.

Restricting timber harvesting to the primary landbase would reduce the long-run sustained yield (LRSY) to 3.4 million cubic metres, about 56% of the 1990 level. A reduction in LRSY typically results in a proportional reduction in AAC.

The short-term landbase (primary plus opportunity) will support a LRSY of 9.8 million cubic metres, or 126% of the 1990 level. Assuming a modest trend in aggregate log prices (0.3% annually), this landbase will expand to support a LRSY of 11.0 million cubic metres. If the log price trend since 1926 of 2% annual increase continues until 2010, the entire available landbase will become operable, and the LRSY will increase to 11.8 million cubic metres.

Forcing the coastal industry to harvest the profile on the short-term landbase results in an annual opportunity cost of $47 million, reducing the net conversion return from $138 million to $91 million. This 34% reduction in revenue would be shared between the industry and the Crown.

The ability of the industry to sustain operations on the primary plus opportunity landbase in the short or long term depends on its flexibility about the order in which it harvests forest stands. Requiring industry to harvest the profile clearly dissipates both profits and rent. The loss of conversion return will be most pronounced in regions where the opportunity landbase is a large proportion of the total operable landbase, as on coastal British Columbia.

The combination of the high elasticity of British Columbia's coastal timber supply and the cyclical nature of forest product markets makes industrial forestry a very uncertain business. Profits for the industry and rent to the Crown will be maximized only if the industry has sufficient flexibility to respond to changing market conditions.

Opportunity Costs of Rules Defining the Timber Harvesting Landbase and Harvesting Order

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Introduction

The size of the landbase upon which timber harvesting may occur and the order in which forest stands are harvested on that landbase are critical factors that profoundly affect the economic benefits derived from the forest.

For the timber producer, the optimal landbase includes all lands where timber can be harvested with a positive net revenue over the productive life of the operation. If timber production is planned to continue in perpetuity, the extent of the timber harvesting landbase is the long run extensive margin. Again for the timber producer, the time value of money encourages the harvesting of the most valuable (highest net revenue) stands first, and of lower value stands later in the harvesting schedule. Any deviations from these economically efficient rules will inflate harvesting costs and reduce operating margins.

On public forest lands the "timber producer" function comprises the owner (the Crown) and the harvesting industry. Governments typically distort economically efficient behavior of firms to produce non-timber benefits for the whole of society.

Recently in British Columbia, two guidelines have been proposed that constrain both the extent of the landbase and the order of harvesting. The landbase upon which the allowable annual cut (AAC) is determined may be restricted to lands where operability is confirmed through past or present performance, and harvesting within the landbase may be required to be distributed proportionately across all forest sites and types. The latter policy is popularly known as harvesting the profile of the forest.

This paper examines the opportunity costs of these policies with respect to timber supply and conversion return.[1] The paper is organized into two major sections, corresponding to the two policies. The first section of the paper describes the relationship between log prices, the extensive margin and timber supply, and quantifies the supply implications of different landbase policies. The second section explores the implications of harvesting the profile of the forest from different landbases. Some general observations on the impacts of the guidelines are included in a final section.

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[1]The opportunity cost of a policy is the benefit foregone through the implementation of that policy. Conversion return is the selling price of logs minus all fixed and variable costs of production. It does not include a return to capital or stumpage fee.

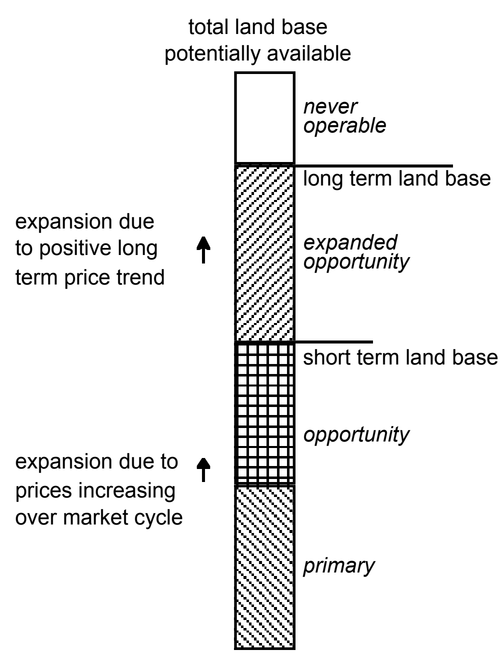
Economic definitions of the landbase

The timber harvesting landbase is the portion of the total land area of a management unit considered to contribute to, and be available for, long-term timber supply. The timber harvesting landbase is defined by reducing the total landbase according to specified management assumptions.[2]

One of these management assumptions states that only lands considered to be economically operable are included in the timber harvesting landbase. Economically operable stands are those in which log prices exceed harvesting costs. The question then arises: if log prices and costs of production determine the extent of the landbase, which prices and costs should be applied? The conservative choice is to identify the landbase that is operable under recent market conditions and operating costs. However, if the landbase is *to contribute to, and be available for, long-term timber supply* [from the Ministry of Forests definition], the landbase should reflect long-term expectations of prices and costs.

Economic operability changes with market fluctuations. The total landbase that is potentially available for timber production and is not reserved for other uses or protected for non-timber forest values can be subdivided to reflect its economic operability at certain critical prices. The *primary* landbase contains those lands that are operable even at the lowest price likely to be encountered in the market cycle. Higher prices within the cycle provide the opportunity to profitably harvest additional lands, referred to as the *opportunity* landbase. The *primary plus opportunity* landbase constitutes the *short-term* landbase, and includes those lands that are economically operable at the highest price likely to be encountered in the market cycle.

Figure 1. Components of the timber harvesting landbase. Arrows indicate the expansion of the operable landbase with increasing log prices.



To complicate matters, log prices exhibit underlying trends as well as cycles. If the price trend is positive and the costs of harvesting remain unchanged, the *short-term* landbase will eventually expand to include the total landbase. The critical price for the *long-term* landbase

[2]This definition is provided in the glossary of the Kalum North Timber Supply Analysis, Ministry of Forests Integrated Resources Branch (1993).

is the maximum price forecasted during the rotation. The remainder of the total landbase is not operable even at the highest price likely to be encountered during the rotation. The relationship between the landbases is illustrated in Figure 1.

The "present performance" landbase proposed by the Ministry of Forests is interpreted for the purpose of this study to be the primary landbase.

Costs of inputs to harvesting

Defining the components of the landbase in terms of critical prices assumes that the costs of inputs to harvesting, such as labour, energy and capital, remain constant. While this assumption is not strictly true, historical input costs show relatively little trend in comparison with prices. Across North America, the cost of harvesting has remained constant or declined slightly over the last four decades, in spite of the steadily worsening biophysical characteristics of the resource. This trend implies that input costs have held steady or decreased, probably due to technological improvements in the harvesting process. From 1960 to 1980 the BC Coast was the only major producing region in North America to experience rising costs. Since 1980 costs have shown little trend. Consequently, it can be conservatively assumed that operating costs will remain relatively constant in terms of real dollars.

To simplify the explanation of the interaction of market forces with the extent of the landbase and harvest levels, total input costs to harvesting will be assumed to remain constant. The increasing operating costs of harvesting more difficult terrain or smaller trees are captured within the analytical system of this study, as described in the next section.

Coastal timber supply curve

The assumption that harvesting input costs will remain constant reduces the determination of the operability limits of the timber harvesting landbase to a question of what prices to apply.

As log price determines the landbase, the area of the landbase largely determines the timber supply. The long run sustained yield (LRSY), a measure of timber supply used in British Columbia, is calculated as the product of the area of the timber harvesting landbase and its maximum growth rate.[3] LRSY is a narrow measure of timber supply; the AAC, a much broader measure of supply, considers inventory levels of standing timber of cutting age, as well as other

[3]The long term maximum production rate of a forest stand is attained when the stand is harvested at the culmination (maximum amount) of mean annual increment (MAI).

factors. Although the AAC is not calculated directly from LRSY or any other measurable characteristics of the forest, a premise of harvest regulation is that the AAC will equal the LRSY in the long run. Consequently, changes in the LRSY usually result in a proportional change in the AAC; the relationship between the LRSY and log price provides a useful indication of how harvest levels might adjust with changing market conditions.

Figure 2 illustrates the relationship among the LRSYs of five timber supply types or aggregations of stands (e.g., all medium site Douglas-fir on Vancouver Island) and the market prices of logs from each type. As log price increases, the operable landbases of the timber types expand, and the LRSY attributable to each type increases. For this analysis, the market prices for each type will be assumed to rise and fall in tandem, maintaining a constant ratio to the volume weighted average market price (π). Note that portions of types 2 and 4, and all of type 5 are available at the indicated market level, but that types 3 and 1 are submarginal. Type 1 is a supply of low value timber that is expensive to harvest.

If π = \$60 and p_1 = \$30, then none of supply type 1 is operable. The volume weighted average market price would have to rise above π', i.e., \$120 + \$30 = \$150, for all of supply type 1 to become operable. For the remainder of this paper, the terms “average log price” and “market level” will refer to the volume weighted average market price of logs on the Vancouver Log Market.

Figure 2. The aggregate supply curve relates total LRSY to average market price. Component timber supply types will have log prices that differ significantly from the volume weighted average market price

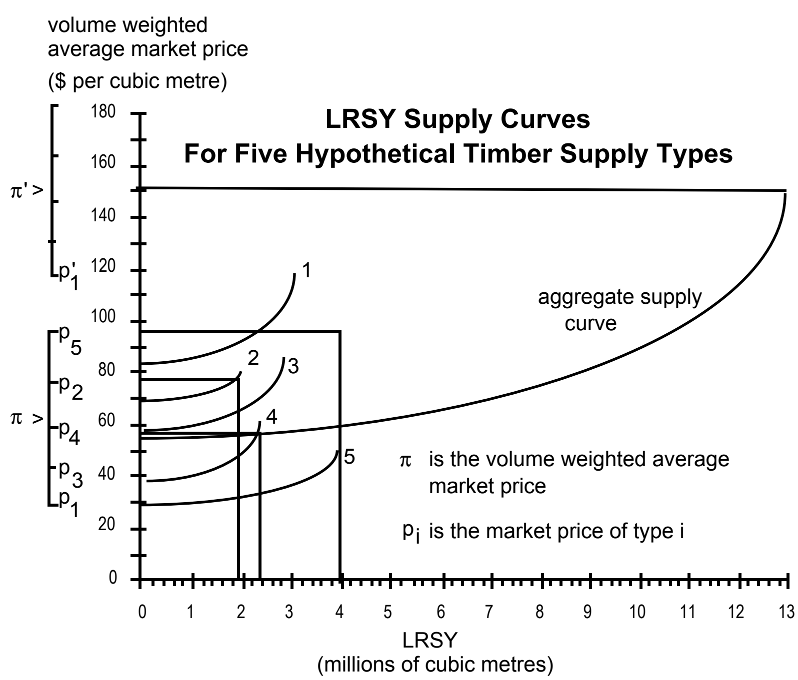
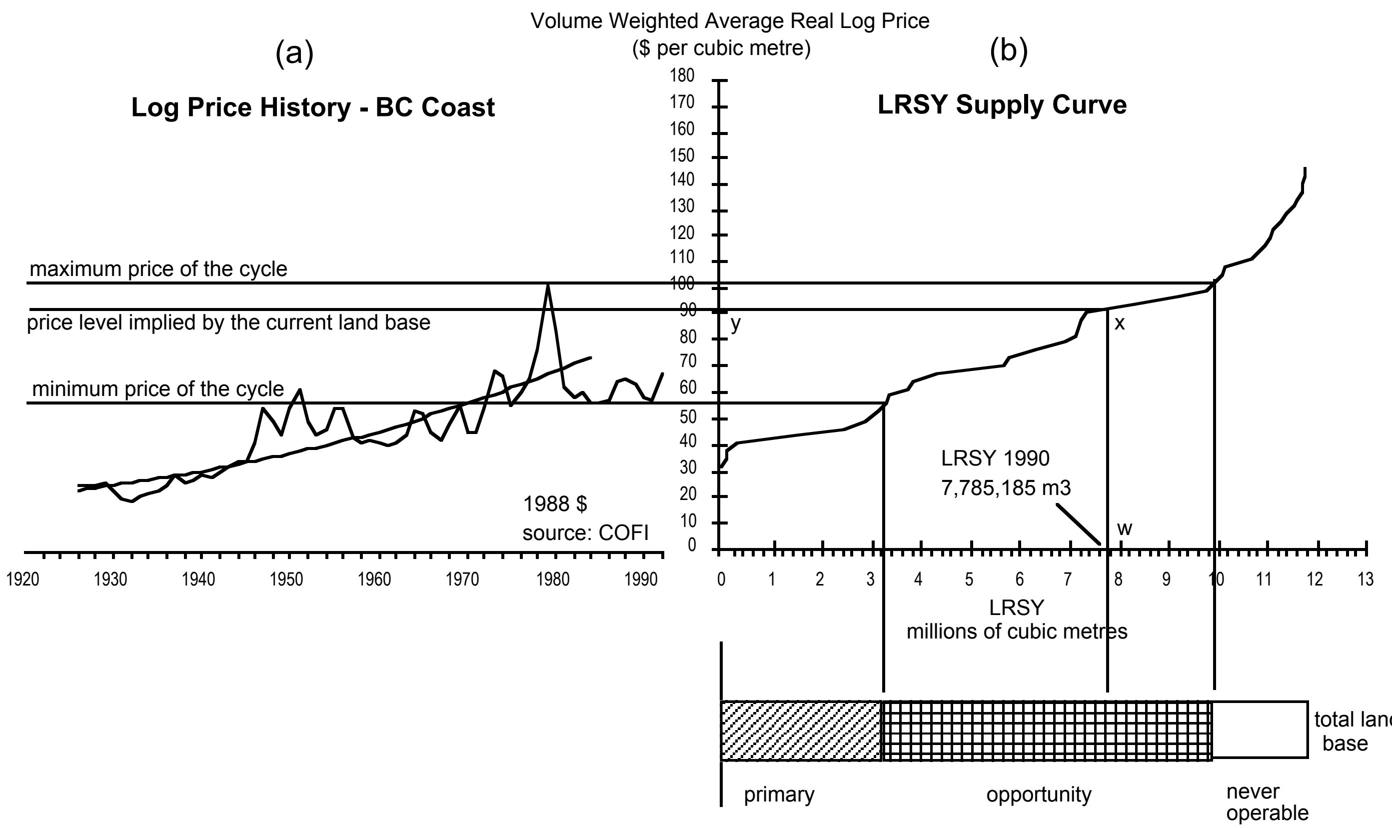


Figure 3 relates the price history of logs on coastal British Columbia to timber supply and the extent of the timber harvesting landbase. The LRSY supply curve (Figure 3b) was determined as part of a separate study, and represents the supply response of coastal TSAs under 1990 management practices and landbase assumptions (Williams 1993).[4]

This aggregate supply curve represents the summation of the supply curves of 46 supply types, plotted against average log price. The supply model that generated this curve determines the operability of a unit of land based on its standing stock of timber. For mature stocks of timber (> 140 years for this study), a land unit is deemed operable if the revenue from harvesting its current timber exceeds its cost of production. Immature timber lands are considered to be operable if they will generate a positive conversion return at some time during their growth cycle.

[4]The juxtoposition of the price history and LRSY supply curve illustrate the dynamic underlying the expansion of the LRSY and the AAC on the coast of BC. Increasing real prices together with improvements in productivity have expanded and sustained harvest levels.

Figure 3. **The timber harvesting landbase of the Timber Supply Areas of coastal British Columbia. In 1990 this area supported a LRSY of 7,785,185 cubic metres (w), which implies an expectation of an average log price of $91 per cubic metre (y)**



Note that the maximum possible LRSY (about 11.8 million cubic metres) corresponds to the maximum extent of the landbase—all physically operable forest land not reserved from harvesting for environmental sensitivity or protection of non-timber forest values.

The timber harvesting landbase in 1990

In 1990, the LRSY of the lands represented by the supply curve was 7,785,185 million cubic metres. Applying the supply curve inversely (tracing from w to x to y on Figure 3b), this LRSY indicates a long-term log price assumption of $91 per cubic metre. The implication is that the identification of the long-term harvesting landbase was based on an aggregate expectation that average log price would reach $91 per cubic metre sometime during the rotation.

Average log prices from 1926 to 1992 are plotted in Figure 3a. All prices are expressed in 1988 dollars to correspond to the cost base of the model used to generate the supply curve. Note that the implied long-term average log price of $91 per cubic metre is less than the peak of the most recent market cycle ($101 per cubic metre in 1979), and in the spring of 1993 (not plotted).

Price levels, landbases and timber supply

The supply curve and price history can be used to identify critical prices that define the primary and opportunity landbases in the short and long term.

The trough of the most recent market cycle occurred in 1985, when the price dropped to $55 per cubic metre. At this price, the supply curve indicates a LRSY of 3.4 million cubic metres for the primary landbase, about 44% of the 1990 LRSY published by the Ministry of Forests.

The market cycle peaked in 1979 and again in the spring of 1993, when the price rose to $101 per cubic metre, and the indicated LRSY increased to 9.8 million cubic metres. Note that 6.4 million cubic metres of this LRSY was from the opportunity landbase.

Determining the LRSY corresponding to the long run landbase requires forecasting future prices. The trend line fitted through the time series of Figure 3a represents a price increase from 1926 to 1984 of 2% per year.[5] Projecting this price trend to the year 2010 indicates a log price of $150 per cubic metre. At this price, the entire landbase that is potentially available for timber production would become operable.

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[5] Source: Council of Forest Industries of British Columbia.

Other studies have recorded similar high rates of price increase of industrial wood in the United States between 1900 and 1950, but these rates have decreased substantially since 1950.[6] A recent study (Simons and Cortex 1992) found that BC coastal log prices had grown 0.3% annually from 1960 to 1989. Applying this rate of increase to the mid-cycle log price of $78.25 for 50 years projects a mid-cycle log price of $91 per cubic metre, with cyclical peaks around $117 and a minimum price of $64. In the year 2040 the primary landbase yields 3.9 million cubic metres annually and the primary plus opportunity landbase yields 11.0 million cubic metres.

Table 1. Timber supply capacities of the short- and long-term landbases under conventional and adjusted yield assumptions

	Conventional Yield Assumptions			Improved Yield: +25%	
Landbase	**Price $ / m^3**	**LRSY x 10^6 m^3**	**% of LRSY in 1990**	**LRSY x 10^6 m^3**	**% of LRSY in 1990**
Short Term					
primary	55	3.4	44	4.2	54
primary plus opportunity	101	9.8	126	12.3	158
Long Term (at 2040, 0.3% annual increase in log price)					
primary	64	3.9	50	4.9	63
primary plus opportunity	117	11.0	141	13.75	176
Long Term (at 2010, 2% annual increase in log price)					
primary	83	7.2	92	9.0	116
primary plus opportunity	150	11.8	152	14.8	189

The difficulty of selecting a landbase in view of its sensitivity to future log prices is compounded by the uncertainty surrounding future yields. Some researchers and forestry professionals maintain that the conventional Ministry of Forests yield curves substantially underestimate the volumes that can be recovered from future stands. Increased yields would have the effect of shifting the supply curve of Figure 3b to the right, increasing the volume of timber produced at each price level.

The implied prices and timber supply capacities of the short- and long-term landbases are summarized in Table 1 for conventional and improved yield assumptions. Under the improved yield scenario, stands are assumed to yield 25% more volume than was estimated by the Ministry of Forests in determining

[6] See Sedjo and Lyons (1990) for a review of these studies.

the 1990 LRSY.[7] Under the improved yield scenario, the short-term primary plus opportunity landbase supports a LRSY of 12.3 million cubic metres, or 158% of the 1990 LRSY.

Opportunity costs of the present performance landbase

The timber harvesting landbase as defined in the proposed guideline, in which operability is determined through past or present performance, is the primary landbase. If the primary landbase is selected as the timber harvesting landbase, LRSY will decrease by 56% from its 1990 level. It is likely that the AAC would be reduced proportionately, consistent with Ministry of Forests practice.[8]

The fear that some stands in the timber harvesting landbase will remain inoperable due to unrealized price expectations, leading to unsustainable harvest levels, is the usual argument for reducing the landbase (and the AAC).

The timber harvesting landbase which supports the current AAC is within the primary plus opportunity landbase as determined by the last market cycle. The TSA landbases were conservatively defined in the 1980s in that the implicit expected future log price of $91 per cubic metre was above the average price of the last market cycle, but $10 per cubic metre below the cycle's maximum price (see Figure 3a). However, the expectation that this price level could be reached sufficiently often over the ensuing rotation to allow the harvesting of marginal stands was not unreasonable as this level has recently been exceeded.

Harvesting behaviour and conversion return

After the timber harvesting landbase has been identified and the AAC determined, the order in which forest stands are to be harvested must be decided. Historically in British Columbia, the rule has been to harvest "oldest first" and to prevent the isolation of patches of timber that could not be profitably recovered in the foreseeable future. Recently, it has been proposed that

[7]Some alternative models estimate yields that surpass the conventional Ministry of Forests estimates by much more than 25%. For example, see Mitchell et al (1992).

[8]AACs may be set above LRSY in recognition of a surplus of mature timber, the requirements of the wood products industry, and the economic benefits to forestry dependent communities. When LRSY drops, the proportional adjustment of the AAC need not be automatic; consideration of the same factors could indicate that the AAC should remain at the same level or be scheduled to adjust gradually to some reduced level.

harvesting be distributed proportionately across all forest sites and types within the timber harvesting landbase—popularly known as harvesting the profile.

As noted earlier, the optimal order of harvesting for an otherwise unconstrained producer is to take the most valuable (highest conversion return) stands first, and schedule the harvesting of lesser value stands later in the rotation. In British Columbia harvesting marginal stands has historically been deferred until it can be done at a profit; submarginal stands are included in the timber harvesting landbase in the expectation that they will become operable later in the rotation.

The requirement to harvest the inventory profile will affect operating margins in three ways: by dispersing the harvesting effort and hence increasing development costs in the short term; by forcing the harvesting of a mix of timber types that may not suit the firm's current milling capacity; and by forcing the harvesting of timber which is submarginal under prevailing market conditions. This last cost, of harvesting submarginal timber, will be used to quantify the cost of the policy of harvesting the profile. Although the other costs are significant they are less tractable analytically and beyond the scope of this study.[9]

For the primary timber harvesting landbase, the rule of harvesting the profile will have no impact, as the landbase does not include any submarginal timber at the lowest price in the cycle ($55 per cubic metre). The total conversion return, shown in Figure 4, is shared between the firm (as return to capital, risk premium, and profit) and the Crown (as rent).

For the primary plus opportunity landbase, harvesting the profile each year without regard to market conditions may force the harvesting of submarginal stands. Any price, π, above the cycle minimum price of $55, but less than the cycle peak of $101 generates a positive conversion return (a surplus) when applied to stands with a harvesting cost less than π. But since the rule of harvesting the profile forces the harvesting of stands with operating costs above π, a deficit will also be generated. If prices are assumed to fluctuate within the market cycle so that the mean price is midway between the market maximum and minimum, i.e., $78 per cubic metre, then the mean surplus and deficit attributable to the opportunity component of the landbase are as shown in Figure 4. The net conversion return attributable to the opportunity portion of the landbase is the surplus minus the deficit. Note that the harvester will be liable for minimum stumpage on the submarginal wood.

Without the requirement to harvest the profile, the more expensive stands would be taken only when the price exceeded operating costs plus minimum stumpage. A conservative scenario for estimating net conversion return for the unconstrained case is that the increments of supply under the deficit in Figure 4 could be harvested at cost, i.e., the operator would time harvests to at least break even. In this case neither an additional surplus nor a deficit would be generated. The conversion returns (surplus and deficit) for the short-term landbases have been calculated for the Coast LRSY supply curve (Table 2).

Calculating the conversion return surplus and deficit for the long-term landbase is more complicated. As the price increases at 0.3% annually from 1990 to 2040,

[9]See Nelson and Hackett (1993) for a detailed discussion of these costs for a coastal watershed.

the critical prices increase and the primary and opportunity landbases expand. Figure 5 shows the critical prices, surplus and deficit at the end of the period of expansion in 2040. The surplus and deficit are calculated annually and the average annual conversion surplus and deficit are recorded in Table 2.

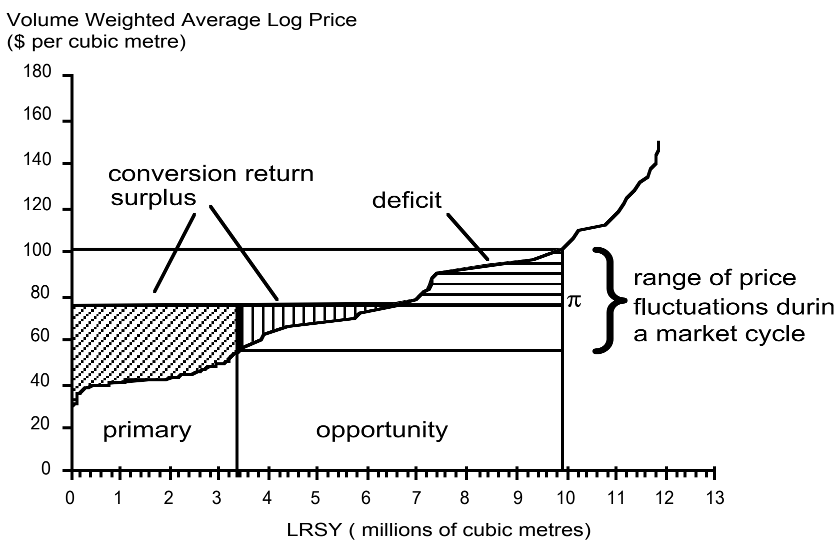
Table 2. Annual conversion return generated by the three landbases under the two harvesting rules

	Unconstrained Harvesting	Harvesting the Profile
Landbase	**Conversion Return Surplus (millions of dollars)**	**Conversion Return Deficit (millions of dollars)**
Short Term		
primary	109	0
primary plus opportunity	138	47
Long Term (at 2040, 0.3% annual increase in log price)		
primary plus opportunity	182	45

Opportunity costs of harvesting the profile

Forcing the industry to harvest the profile on the short-term landbase (primary plus opportunity lands) results in an annual opportunity cost (in the form of a conversion return deficit) of $47 million, reducing the net conversion return from $138 million to $91 million. This 34% reduction in revenue would be shared between the industry and the Crown.

Figure 4. Harvesting the profile reduces the net conversion return when the harvest level is based on the primary plus opportunity landbase



Unconstrained harvesting of the long-term landbase (as defined by a 0.3% increase to 2040) would yield an average annual net conversion return of $182 million. The average annual opportunity cost of constraining the industry to harvest the profile is $45 million, but this cost would be much larger in the earlier years of the projection period, and would shrink as prices increased.

Assumptions regarding harvesting behaviour and price cycles

The validity of the foregoing analysis and estimates of opportunity costs depends on many factors, but two assumptions are particularly critical.

The first assumption pertains to the situation of a firm harvesting at a rate determined for a landbase consisting of primary plus opportunity lands. The assumption is that the firm will react to price increases within a price cycle by reallocating harvesting effort to the expanding extensive margin in the opportunity landbase, rather than concentrating the harvest in high margin stands of the primary landbase. If the firm does not take advantage of the cyclical price movements to harvest timber from the opportunity landbase, the harvesting rate (which is based on the primary plus opportunity landbase) may not be sustainable. Of course, if the underlying price trend is sufficiently strong, the primary landbase will expand fast enough to sustain the harvest. For a firm to react to short-term price movements, it must have sufficient developed timber on the opportunity landbase and have appropriately flexible logging and milling systems.

The second assumption relates to the distribution of prices within a market cycle. The explanation of the relative sizes of the conversion return surplus and deficit on the opportunity landbase assumes that the mean and median price of the cycle are the same. If the price distribution was skewed such that lower prices occurred more often and price spikes were infrequent, the expected value of the producer surplus would be smaller and the deficit (i.e., the opportunity cost of cutting the profile) larger. The cycles of the aggregate price series of Figure 3 do not appear to demonstrate this behaviour, except for the most recent market cycle (1979 to 1993).

Other caveats

The sensitivity of the supply curve to yield assumptions, and all results derived from it, was demonstrated with a sensitivity analysis (Table 2). A similar degree of sensitivity of the supply curve to cost and price assumptions has been demonstrated in other studies by the author.

Another consideration is that the supply curve was developed to reflect the timber supply planning practices of 1990, and does not incorporate the effects of the numerous integrated resource management (IRM) objectives which are part of the current analyses. Since the net effect of the IRM objectives is to reduce the timber harvesting landbase, extend rotation ages, and increase harvesting costs, the supply curve is expected to shrink to the left and lift or stretch vertically, i.e., a reduced supply at higher cost.

All of these considerations will affect the magnitude of the opportunity costs of the two policies but will not affect their signs, nor the basic assertion of the analysis that each policy imposes a substantial cost to the industry and the Crown.

However, a more serious consideration is that this analysis is essentially static — the LRSY supply curve expresses the productive capacity of a landbase in the long run, but provides no information on the ability of a forest to sustain a level of harvest in the short run until the transition to the LRSY is complete. To demonstrate the sustainability of operations on a landbase, the aggregate timber supply variables must be modeled, a long-term harvest schedule applied, and the forest dynamics projected for one to two rotations.

Final comments

Clearly the timber harvesting landbase and hence timber supply, is highly elastic with respect to log prices. This finding is consistent with earlier studies of the BC Coast and underlines the need for a rational and consistent policy for the definition of economically operable landbases (Williams and Gasson 1986; Cardellichio *et al* 1988; Williams 1988).

Restricting the timber harvesting landbase to lands that were economically operable continually during the last market cycle would reduce LRSY to 3.4 million cubic metres, about 56% of the 1990 level. It is anticipated that AACs would be reduced proportionately.

Basing the AAC on the short-term landbase (primary plus opportunity) will support a LRSY of 9.8 million cubic metres, or 126% of the 1990 level. Assuming a modest trend in aggregate log prices (0.3% annually), this landbase will expand to support a LRSY of 11.0 million cubic metres. If the log price trend since 1926 of 2% annual increase continues until 2010, the entire available landbase will become operable, and the LRSY will increase to 11.8 million cubic metres. The increasing global scarcity of logs suitable for the production of appearance grade lumber will result in upward pressure on the prices of those logs, and supports the argument that the long-term trend of increasing log prices will continue for the coast of BC.

The short- or long-term ability of the industry to sustain operations on the short-term landbase depends on its flexibility about the order in which forest stands are harvested. Requiring firms to harvest the profile clearly dissipates both profits and rent by 34% on the short-term landbase. The loss of conversion return will be most pronounced in regions where the opportunity landbase is a large proportion of the total operable landbase, as on the coast of British Columbia.

To avoid these opportunity costs, it has been proposed that the assessment of whether a firm is cutting the profile be done every five years. However, it is unlikely that complete market cycles will fit within a five-year term and the industry will be unable to avoid harvesting submarginal timber under poor market conditions.

The combination of the high elasticity of British Columbia's coastal timber supply and the cyclical nature of forest products markets makes industrial forestry a very uncertain business. Maximum profits for the industry and rent to the Crown will be generated only if the industry has sufficient flexibility to respond to changing market conditions.

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