Coast Forest Region

Ministry of Forests and Range

Operability Mapping Technical Reference

Submitted to:

Ministry of Forests & Range
Jim Brown, RPF
Timber Supply Forester
Coast Forest Region
(250) 751-7260
WJim.Brown@gov.bc.ca

Prepared by:

Mike Landers, B. Econ, RPF
Resource Analyst / Planning Forester
Forsite
(250) 286-3806 ext. 3
mlanders@forsite.ca

November 20, 2006

TABLE OF CONTENTS

Executive Summary

In March of 2006 the Ministry of Forests - Coast Forest Region contracted the completion of an operability review for their region. The operability review document identified several limitations to implementation of further assessments. This document expands on many of the barriers and intricacies encountered during economic operability assessments. The objective for this is to be a resource document for forest practitioners completing operability assessments. The intent is to bring a commonality to the considerations, inputs and components of economic operability assessments such that future assessments are more transparent, repeatable and defendable.

Operability mapping is a strategic planning tool used to help identify the portion of the forested land base where forest harvesting is expected to be physically and economically feasible. Its primary use is in strategic planning work that requires an understanding of the extent of the land base that will be accessed in the future for timber harvesting.

The report which follows describes the cost and value dynamics that must be evaluated and incorporated into an economic operability assessment. Approaches to operability mapping are discussed and evaluated. Model design is described and finally key recommendations regarding the use and continuance of economic operability assessments are provided.

The document is to emphasizes that the timber harvesting land base is a dynamic entity changing rapidly with economic pressures. The timber harvesting land base identified in an economic downturn will be very different from one identified in a booming economy. It should be viewed as critical to prevent short sighted decisions made during an economic downturn or recession from removing future long term timber supply opportunity. Similarly it must be recognized that the contributing landbase could be overstated in top-of-the-market conditions. Identifying and measuring the contributing land base in this manner will insure that full opportunity cost accounting is possible and evident to support and report on land use planning initiatives.

Acknowledgements

The cooperation and contributions from several key people have lead to the successful implementation of this project. The following people have contributed to and shaped the outcome of this project:

Ministry Staff:
Jim Brown, Timber Supply Forester, Coast Forest Region
Christine Fletcher, Manager, Policy and Development, Victoria

Forsite Contributors:
Cam Brown, Strategic Planning Forester
Ian Robertson, Program Coordinator

Other Contributors:
Lazslo Kardos, Independent Consultant (Interfor Administrative Forester during phase 1)

1 Introduction

In March of 2006 the Ministry of Forests and Range - Coast Forest Region contracted the completion of an operability review for their region. This review assessed the current condition of operability mapping in each of the coastal Timber Supply Areas (TSA), identified barriers to implementation of new operability assessments, and ranked each of the TSAs based on the need for updated operability mapping. A report reflecting these findings was submitted in April 2006[1].

This initial phase of the project identified several limitations to operability assessments and lead to the development of the reference material presented in this report. This Phase II document provides a summary of issues that should be considered prior to undertaking an operability assessment. The intent is not to provide rigid guidelines that must be followed but to identify areas of concern and discuss critical issues so that future operability assessments are steered in a common direction. Basic principles are identified and discussed.

This document should serve forest practitioners as a robust and comprehensive reference document which identifies and discusses the intricacies of operability mapping in the Coast Forest Region.

2 Operability Mapping Overview

Operability mapping is a strategic planning tool used to help identify the portion of the forested land base where forest harvesting is expected to be physically and economically feasible. Its primary use is in strategic planning work that requires an understanding of the extent of the land base that will be accessed in the future for timber harvesting. For example, it is a key input into Timber Supply Review (TSR) analyses designed to support Annual Allowable Cut (AAC) determinations. Thus, operability mapping is most valuable in areas that have not been previously developed. Previously harvested stands are typically assumed to be operable because the site was previously operable. Future harvest entries are expected to be less costly assuming the infrastructure developed in the first harvest can be used in subsequent entries.

"Operability mapping" is a phrase which may mean different things to different people, but from a TSR perspective the definition should be independent from integrated resource management constraints or environmental sensitivities. These factors are elements which should be considered separately from operability such that the opportunity cost of their accommodation can be measured. Operability assessments should be based strictly on the *physical and economic* feasibility of timber harvest.[2] This definition is the one which prevails in industry and government as the accepted standard.

<u>Physical Operability</u>:

This is the subset of the land base where existing harvest systems could feasibly operate to remove timber. With the advent of systems such as heli-logging and long-line skylines, very

---

[1] Coast Forest Region Operability Review, Forsite Forest Management Specialists, April 2006

[2] This definition is consistent with the Forest Investment Account (FIA) operability standards document written by Forest Analysis and Inventory Branch (MoF Victoria): www.for.gov.bc.ca/hcp/**fia**/land base/OperabilityStandards.pdf

little if any of the forested land base is now considered physically inoperable. Cost not withstanding it is possible to remove any tree from anywhere in a TSA. Thus, the task of defining physical operability is better viewed as harvest system mapping – that will allow economic considerations to be meaningfully incorporated.

Economic Operability:

This is the subset of the land base where it is economically viable to harvest timber and regenerate the site under a given set of cost and value assumptions. Stands are evaluated relative to expected costs (i.e. planning, road construction, logging, hauling, silviculture) and values (i.e sawlog volume x value, pulp volume x value). This net value can then used to evaluate operability by defining a threshold over which stands are considered operable. For example, a positive net value may indicate operability.

The operable land base should be viewed as dynamic, capable of changing significantly over time as a result of forces that change economic conditions. Economic operability is influenced by a number of internal and external forces to the forest industry. Several examples of these forces are described below:

1. Technology affects economic operability on both the harvesting and milling side of the equation in the following ways:
    a. Improvements in harvesting technology will reduce costs making stands which once appeared economically inoperable more attractive;
    b. Improvements in milling technology will allow products to be produced at less cost, potentially making it possible to pay more for logs (higher log values).
    c. Changes in wood use technology (manufacturing and construction) allow producers to develop new markets and penetrate existing ones adding value to the final product which in turn puts new demand on resources and increases log values.
2. Politics and government policy are externalities which are capable of putting pressure on costs and prices in the following ways:
    a. Foreign building codes may change rendering existing product lines less valuable (the opposite is also true though not likely to occur);
    b. Increased regulatory requirements can increase costs lowering the net value of stands,
    c. Stumpage rates and appraisal **policy** may increase or decrease the net value of stands.
3. International trade policy and world markets can have huge impacts on domestic markets putting intense pressure on price and value with little or no warning in the following ways:
    a. Fluctuating currency values and exchange rates impact revenues in positive and negative ways dependant on the direction of the movement in rates and corporate exposure;
    b. Trade disputes can result in protectionist tariffs and countervailing duties being imposed which limit market access reducing demand causing prices to fall making marginal stands less viable;
    c. Quotas may be imposed skewing the economic operability threshold between producers with quota and those without.

All of these points noted can potentially influence costs and/or values in a typical business cycle. The above is not intended to be a comprehensive list but rather an illustration of the range of possibilities putting pressure on economic operability thresholds illustrating the range of issues that may impact the data sources used in economic operability assessments. Uncertainties regarding the movement of these pressures (the absence of perfect information) make it difficult to choose a market condition which represents an average or range of expected future market conditions. A more detailed review of cost and value drivers is presented later in this report.

Since economic operability is dynamic over time and a single static operable land base definition is typically required for a TSR process, assumptions must be made to simplify the situation. Consideration must be given to current and historical conditions and those that are likely to present themselves in the future because the result is meant to be used in a long term strategic planning process. This step is obviously a critical one that is subject to significant discussion because we cannot predict the future with a high degree of certainty. Further discussion of this issue is presented later in the report.

2.1 Desireable Attributes of Operabiltiy Mapping

An operability 'mapping' exercise that has the following attributes is likely to provide a quality product that has the support of all stakeholders in a management unit:

1. Repeatable – the process used to arrive at the result must be well documented and structured such that it could be repeated and provide similar results (transparent). Repeatability in an economic operability assessment is desirable to ensure that subsequent iterations of the model to address new information or answer "what-if" scenarios are easily addressed.
2. Defendable – the process must be able to stand up to scrutiny (peer review) and be based on agreed upon data inputs (cost and value inputs). This process must be based on documented and fully vetted assumptions that are supported by facts, data and analysis as necessary to substantiate the assumptions and associated conclusions that were used to "build" the model.
3. Adaptable – the process model would ideally be able to adapt to changes that occur when better information becomes available or when assumptions change.
4. Best Use of Data – uses data that is considered reliable and reasonably accurate. Avoids use of known questionable data.
5. Locally Relevant - makes use of local knowledge / expertise / data sources (costs/values) where available. Each management unit has a significant store of local knowledge available that can be harnessed to add value to any assessment. The full picture can rarely be fully reflected in standard digital datasets (local neighbourhood issues).

Ensuring consistency with these principles when designing an economic operability assessment will result in a robust model capable of adapting to changes and gaining acceptance by stakeholders.

3 Approaches for Defining Operability

Defining operability has always incorporated economic considerations. Historically, it has been more subjective and based on local knowledge, while more recently it has become more objective and automated because of the need to address the dynamic nature of economic operability.

The sections which follow describe the techniques that have been used to identify the operable land base. They range from simple/inexpensive approaches to more complex and costly approaches.

3.1 Sketch Mapping

Sketch mapping involves a manual review of maps and photos using local knowledge of operational considerations, harvesting practices/costs and typical stand values. This expert review is done by drawing lines or zones on forest cover maps and/or orthophotos with the reviewer making judgment calls around whether broad areas are economic to access, log and regenerate. Some field based (typically helicopter) reviews are generally incorporated into this assessment. Values and costs are not explicitly calculated – only a subjective consideration of these factors is used to define whether stands are economic or not.

Pros:	**Cons:**
1. Simple and quick 2. Least expensive (if digitizing is ignored and helicopter time is limited) 3. Makes use of local knowledge/expertise (engineering options, stand values, etc) 4. Relies less on inventory data so a potential option if inventory data is poor.	1. Relies heavily on subjective opinions (not very repeatable, defendable, or adaptable) 2. Doesn't make full use of available inventory information – too much to consider at once and limited use of stereo imagery occurs. 3. Changing economic conditions are not readily considered or addressed – rooted in the economic situation currently understood by the mapper.

3.2 Stereo Operability Mapping

Stereo operability mapping is essentially the same as sketch mapping except it is involves the dedicated use of stereo photography (i.e. digital softcopy or analytical stereoplotter) and digital data (contours, forest cover attributes). This suite of tools allows evaluation/confirmation of forest cover attributes and roading feasibility at a coarse level and provides the planner with additional information (species/ages/volumes) to make economic determinations. The use of computer mapping systems tends to allow more data to be meaningfully in the assessment because it is available digitally. Ultimately the planner is still making subjective judgment calls about whether specific geographic areas are economic to access, log and regenerate. Some field based (typically helicopter) reviews are generally incorporated into this assessment.

Pros:	**Cons:**
1. More detailed than sketch mapping as more information is at the finger tips of the mapper. 2. Makes use of local knowledge/expertise (engineering options, stand values, etc) 3. Allows a confirmation of inventory data so is a potential option if inventory data is poor. 4. Allows for evaluation of some engineering issues (road grades, bridge crossings, etc)	1. Relies heavily on subjective opinions (not very repeatable, defendable, or adaptable) 2. Changing economic conditions are not readily considered or addressed – rooted in the economic situation currently understood by the mapper. 3. More expensive than simple sketch mapping.

3.3 Stand Level Economic Assessments

Improvements in Geographic Information System (GIS) technology in the last decade have enabled a much finer resolution for tracking, analyzing and measuring inventories of all sorts across huge landscapes. This has allowed new methods for measuring operability to be explored

As the name implies, stand level economic assessments assign an economic value and cost to each stand in a GIS system in order to derive a net stand value. Values are assigned based on anticipated log volumes, log grades, and grade values, while costs are assigned to reflect all delivered wood costs including regeneration silviculture. Costs that are typically amortized over multiple stands (i.e. road development, camp costs, etc) must be prorated to each stand. Once a net value for each stand is determined, a threshold value can be selected to define operability and the relative values for stands across the land base is clear.

There are numerous approaches to assigning values and costs to stands and this is the subject of the later part of this document. Several example approaches are:

1. Apply localized appraisal costs/values based on parameters such as species, age, site index, BEC, slope, terrain class, distance to mill/dump, etc, (use primarily existing data);
2. Predict future road networks to assign harvest systems, complete engineering overview assessments to assign access costs, and then apply typical appraisal costs/values (adding some custom datasets)
3. Develop localized costs/values based on operational data. Link real costs/values experienced in the management unit to forest cover polygons using a process similar to the appraisal based approaches (use primarily custom datasets).

When run using multiple market assumptions (low, median, high markets), the land base can be clearly divided into two categories:

1. Core Operable area (operable in most market conditions)
2. Marginal Operable area (operable only in some market conditions)

The challenge becomes to define how much of the marginal operable area should be included for analyses such as TSR. If a stand is only economic at the peak of the market cycle, how likely is it that it will get logged? Where does the threshold lie?

For context on this issue, a recent study completed in the Kingcome TSA[3], showed the operable land base varying between 423,571 hectares using 1995 maximum log values and 142,730 hectares using 2004 minimum log values.

This approach can result in a very different product than the first 2 options because it may produce a spatially mixed result ("salt and pepper mapping"). This type of assessment typically is not able to adequately consider a stands context relative to its neighbours. Low value stands surrounded by high value stands require a different economic threshold than the reverse. High value stands may subsidize development of low value stands depending on the spatial distribution of the harvest opportunity.

[3] Economic Operability Assessment of the Kingcome Timber Supply Area, Timberline Forest Inventory Consultants Ltd, Undated.

Pros:	**Cons:**
1. Repeatable, defendable, adaptable, transparent, and objective. 2. Allows exploration of numerous market conditions very quickly (automated). 3. Costs can be quite reasonable if existing datasets are used (however reliability suffers) 4. Provides relative net stand values across the land base so they can be stratified into economic classes (i.e. core operable, marginally operable)	1. Tends to use less local knowledge/expertise (engineering options, stand values, etc) because of automation. 2. Typically does not address 'neighbourhood' issues well (value of adjacent stand can influence whether stand of interest is operable). 3. Tends to be heavily dependant on forest cover data so reasonable data is needed. 4. Costs can be high if lots of custom datasets are developed (however reliability increases).

3.4 Woodshed Economic Analysis

Woodshed economic analysis produces an evaluation of economic viability for a broader grouping of stands that form some logical development unit – the "woodshed". A woodshed is typically defined as an area which is serviced by a common wood gathering point. This type of analysis is most relevant when no operability mapping exists and large areas must be addressed quickly.

In a recent assessment of the Central Coast[4] area the objective was to estimate a mean stand value (mean value/m^3 less the mean cost /m^3) of a number of woodsheds. The approach relied on a previously defined THLB, and then attributed harvesting costs using an engineering overview assessment and the Coast Appraisal Manual[5]. Stand values were derived using average grade distributions based on historical grade data from Revenue Branch. Each woodshed was then assessed for net value and was then considered operable or inoperable based on a predetermined minimum threshold criteria.

This approach is appropriate when stand level attribute information is not reliable enough to predict log grades/values or when local/neighbourhood issues cannot be sufficiently addressed through a stand level value assessment. The challenge is to arrive at a reasonable THLB area within each woodshed as it will have significant implications on the woodshed averages. If too many marginal stands are included in the projected THLB, the woodshed as a whole may report a negative average value while a different combination of stands may otherwise prove to be economic.

---

[4] Assessing Current Timber Harvesting Value in the Central Coast, Timberline Forest Inventory Consultants Ltd, August 2000

[5] Coast Appraisal Manual Effective as of 1 April 2000. British Columbia Ministry of Forests. http://www.for.gov.bc.ca/hva/manuals/coast/2000/CoastAprilMaster2000.pdf

Pros:	Cons:
1. Repeatable, defendable, adaptable, transparent, and objective. 2. Allows exploration of numerous market conditions very quickly (automated). 3. Can consider neighbourhood issues well because stand level comparisons are avoided by using mean net stand values. 4. Provides coarse level operability assessments for large areas with no existing operability planning.	1. Is very coarse and can only serve to shrink the THLB used as an input. The size of the THLB used can directly impact results because entire woodsheds are included/excluded based on the mean net stand value. 2. Tends to use less local knowledge/expertise (engineering options, stand values, etc) because of automation.

3.5 Combination Approaches

As each of the approaches described about have strengths and weaknesses, ideally a combination of options would be employed. For example, stand level economic assessments can be included in either of the sketch mapping or stereo mapping processes as context information. This allows local knowledge to be better combined with objective economic analysis and eliminates some of the issues around poor consideration of neighbourhood issues. Stand level economic assessments often generate salt and pepper results where stands in close proximity are included and excluded from the operable land base. Completing a process of drawing operability lines based on these patterns will eliminate much of this noise and reflect the reality that marginal stands beside high value stands are more likely to be logged than marginal stands on their own.

4 Economic Operability Model Design

The following section takes the Stand Level Economic Assessment options introduced above and explores potential methodologies and issues more completely. This approach to operability mapping is being used more frequently and this section is meant to be a resource for understanding how it can be completed and its strengths and weaknesses.

The development of an economic model requires knowledge regarding the data sources available to populate and “run” the model. Prior to commencing a project to evaluate economic operability data sources and data quality must be evaluated.

Accurate, reliable and regionally relevant data will forecast results with the greatest level of confidence. However, perfect information is a hypothetical situation which will never occur in reality. In a perfect information situation all variables are fully understood and producers and consumers knowledge regarding the “information” is complete and identical. The cost associated with collecting perfect information and constantly updating it would be prohibitive. However, the best available information will provide results that are more reliable and useful in subsequent analysis. The difficulty associated with data acquisition is that of cost. Pursuing perfect information is cost prohibitive as are the many levels of near perfection. In a competitive marketplace where perfect information is not available firms must decide how much effort to dedicate to data collection. The amount of effort applied will be a function of the firm’s willingness to accept risk that the information used to base decisions may be inaccurate or simply wrong.

In the case of a public property resource such as the forests of British Columbia, forest resource professionals and government must collect sufficient information to protect the public interest, while recognizing that the information they have to base their decisions upon will not be perfect.

Frequently, in a common property situation where the government is trying to collect information regarding cost and value, firms may not be willing to divulge this information in spite of the fact that doing so is to facilitate better management of the resource. Most firms will view this information as confidential and relevant to their strategic positioning in the marketplace. Therefore, it is the responsibility of those charged with this public trust to understand the data shortcomings and be able to identify and quantify them. Once this data uncertainty can be quantified the resource managers can then evaluate the need, merit and expected benefit from additional data collection effort.

4.1 Inventories

Inventories are the backbone of stand level economic operability analyses and the quality of the inventories used in the analysis will directly define the reliability of the results.

Forest cover (vegetation) inventory is the primary layer from which many of the economic factors are derived. Weak or unreliable inventory data is a substantial impediment to producing a stand level economic operability model. Economic operability assessments based on unreliable inventory are of little value as they produce results that do not reflect reality in the field. If forest cover inventory is poor – it should likely be updated before proceeding with a stand level assessment.

Site index adjustments should be considered for the managed stand in the forest cover if they have not already been completed. If no site series ecosystem mapping is available to do site index adjustments by site series (SIBEC), surrogate approaches could be used. One such surrogate is the Old Growth Site Index (OGSI) adjustment base on paired plot sampling[6]

The following inventories are also very useful as part of a stand level economic assessment:

- TRIM (terrain) data provides attributes such as slope and elevation that can help to predict harvest and regeneration costs.
- Terrain stability mapping helps to indicate where harvesting and road building costs can be expected to be higher.
- Existing road networks help to define the currently accessed land base (lower roading costs) and planned road networks help to define where conventional harvest systems can be employed in the future vs helicopter systems. Road systems combined with mill/dump locations also help to derive hauling cycle times that drive hauling costs.

[6]Nussbaum, A.F., 1988. Site Index Adjustments for Old-growth Stands Based on Paired Plots, A.F. British Columbia Ministry of Forests. http://www.for.gov.bc.ca/hfd/pubs/Docs/Wp/Wp37.htm

4.2 Cost Modeling

Cost modeling is the task of developing a way to assign a timber extraction cost (usually expressed as $/m³) to each polygon (stand or portion of a stand) in the inventory. Developing a cost 'model' or equation to predict costs involves the investigation of the factors that define 'cost' and how those factors behave in the marketplace. Costs must include everything from corporate administration to final delivery to the customer. Large tenure holders may maintain processing facilities so the 'cost' of the raw material is merely an internal transfer payment between subsidiary companies. The structure of the enterprise (i.e. Limited company with one or many subsidiary companies) and the type of harvesting license the who that final "customer" is may vary. Whereas raw material costs for small produces represent actual costs incurred. For the purpose of an operability assessment, we are focused on the cost of converting a stand of trees into logs and delivering them to some predefined point (i.e. a mill, dump, or point of sale). The point of delivery should reflect the location where, once delivered, payment for the logs is made.

<u>Cost Equation:</u>

Development of a cost equation should consider all of the attributes listed in Table 1. Many of these cost attributes will not be presented in the format listed and the onus will be on the data collection phase of an economic operability assessment to ensure that each of these items has been accounted for and that no double counting has occurred as a result of grouping of the parameters listed. Frequently, cost factors are grouped into baskets of related costs. Grouping practices may also vary between operators presenting additional complexity in sorting out what the benchmark cost is for the area of interest. An example of typical cost groupings is illustrated in Appendix 1.

A controversial road cost is road amortization. Road amortization is frequently reported as a cost heading with little or no explanation as to what has been included in this figure or how long the amortization period is. How road amortization is calculated is further complicated by individual company accounting practices. Operators are very likely to have different views and definitions of capital and expense roads and how they report them.

Table 1. Cost Equation Attributes

Cost Attribute	Units/Reference Measure
Overhead (corporate admin etc…)	Value ($\$/m^3$)
Forestry (include all planning)	Value ($\$/m^3$)
Engineering (include oologists[7])	Value ($\$/m^3$)
Crew (include transportation)	Value ($\$/m^3$)
Road construction	Value ($/km)
Reactivated road	Value ($/km)
Road maintenance	Value ($\$/m^3$)
Falling	Value ($\$/m^3$)

[7] Oologists refers to additional professional services provided by but not limited to: biologists, archeologists, geologists, and professional engineers.

Cost Attribute	Units/Reference Measure
Conventional yarding & loading	Value ($\$/m^3$)
Helicopter yarding & loading	Value ($\$/m^3$)
Hauling	Value ($\$/m^3$)
Haul Distance	km
Dumping, Sorting	Value ($\$/m^3$)
Barging ,Towing	Value ($\$/m^3$)
Tabular road	Value ($/km)
Camp maintenance	Value ($/km)
Camp supplies	Value ($)
Taxes	Value ($\$/m^3$)
Silviculture	Value ($\$/m^3$)
Access Development costs	Value ($\$/m^3$)

The cost equation should also include a means to address cost increases over time. Cost increases can be both expected such as 'inflation' and unexpected such as sudden jumps in fuel and energy costs. The cost of inputs to harvesting cannot be assumed to be static. For example the dramatic increases in energy costs in the past two year period (2004-06) are a dramatic illustration that historical trends are just that, history with no guarantee as to future performance. While it may be appropriate at a corporate planning scale to assume that harvesting costs will remain constant in the short term the responsibility of forest land managers is for a long term timber supply. The cost equation should be able to respond to changes in all aspects of its inputs such that sensitivity analysis and analysis of subsequent situations can be evaluated with ease for comparison.

The cost equation must also consider that some attributes of cost are based on fixed costs prorated over an anticipated harvest volume (i.e. mainline development) while other costs are variable and fluctuate in correlation with the harvest volume (i.e. felling costs). A fixed administrative cost (such as office rent) will decease per meter as more meters are harvested and the opposite is also true. This can have a substantial impact on margins and net revenues in declining harvest opportunity situations. Meanwhile a variable cost such as road maintenance is more likely to vary independently of the number or kilometers of road under permit. If the roads are not being used and the weather is good the maintenance costs will be less than if full production is being transported over the road network and the weather is inclement. These economies of scale (or diseconomies of scale as the case may be) must be considered when projecting costs.

Road costs can be broken down into developed and undeveloped based on primary access infrastructure being in place or not. In situations where a woodshed is not serviced by an established wood collection point there will be additional costs associated with initial development of infrastructure. These additional costs need to be factored into the development of a cost model. How these "start-up" costs are amortized over the transportation network and the harvest volume is dependant on the life expectancy of the project and the gross volume expected.

Cost equations must also consider the dynamics of local neighborhood issues. Local neighborhood issues are similar to those of the woodshed scenario previously discussed. In this case the dynamics are at the stand level. Operability of a given stand can be heavily influenced by neighboring stand attributes. Fixed costs such as such as camp establishment, log dumps, or expensive bridges must be recognized and prorated over the range of stands accessed by the investment. Road construction unit costs ($/m^3) are also influenced by the first pass volume that can be accessed from the road system so the amount/value of stands in the local 'neighborhood' can directly impact stand specific costs.

Marginal stands that might not otherwise be logged may be considered operable if they are surrounded by higher value stands that reduce the costs of access. Figure 1 illustrates this situation. If the infrastructure will be built to develop the 700 m^3/ha block the incremental cost to develop the 550 m^3/ha block may make the 550 m^3/ha block economically viable. Meanwhile the 300 m^3/ha block will now have a road running right through it making it potentially viable too. The 700 m^3/ha block will have effectively subsidized the development of the other two areas independent of stumpage and appraisal considerations.

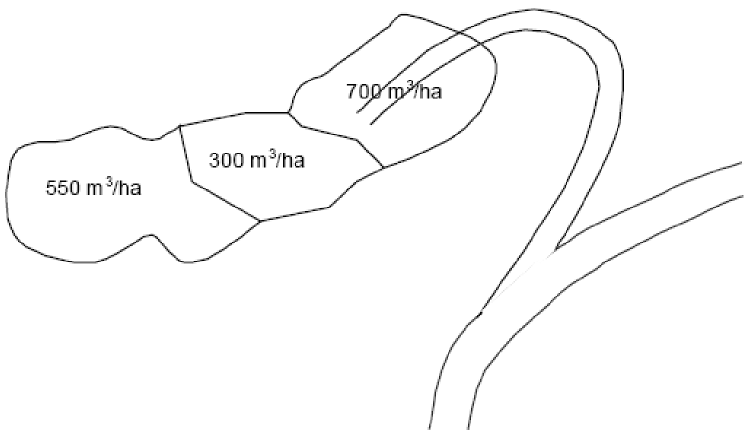

Figure 1. Local neighbourhood stand proximity[8]

Data Sources:

Locally specific data sources that are directly linked to the plan area are the best source for cost estimation. The primary qualification to attach to this type of data involves incorporating more than one source and therefore, reporting format (i.e. more than one organization is providing cost data) into the modeling parameters. Building cost models on locally specific data is usually worth the additional effort because this effort will go a long way towards removing much of the uncertainty that would otherwise cast doubt on the results. Efforts to collect data in this manner typically involve data use agreements and these agreements should be set up ahead of time with independent third parties to facilitate forthright data collection. The proprietary nature of this information previously mentioned

[8] Figure taken from FIA Standards for Operability Mapping, MoF Forest Analysis and Inventory Branch, May 8, 2003. http://www.for.gov.bc.ca/hcp/fia/land base/operability.htm

demands that the integrity of an analysis using this information be steadfast. Otherwise future projects and analysis will be met with resistance and reluctance to participate.

An alternative to project specific data is the data collected from the annual cost survey. The cost survey annually surveys coastal logging and forest management costs. The cost survey collects consolidated data based on operating area and tenure. Data from the cost survey is collected to determine appraisal cost estimates in the stumpage and appraisal system. The appraisal manual also is a source of average cost which may be an alternative if no better cost attributes exist. The hazard with appraisal manual data is that it is generalized and many not be sufficiently representative to base fine resolution analysis upon. If cost survey data is used it should be evaluated to ensure that it is representative of the operators in the plan area capturing the complete range of costs.

Projected Road Infrastructure:

A projected road infrastructure is the cornerstone of building a cost model equation. Without a projected development infrastructure evaluations regarding timber access cannot be completed and many stands are likely to be overlooked. Increasing the level of detail at this stage will facilitate greater confidence in the results provided by the final modeling exercise. The land base would ideally be thoroughly investigated to identify potential development barriers. Each of these barriers should then be evaluated on the ground if possible to determine their merit based on current construction techniques that are available. Environmental factors should be noted but should not fetter the decision at this stage. Where cost concerns prevent this type of assessment, typically road development costs could be assigned based on slope and terrain classifications.

Access development projections will draw upon several resources to complete the process. Local knowledge and expertise will play a key role in this aspect of the design. In situations where a perceived barrier is reported this barrier should be re-evaluated with each new economic operability assessment to ensure that complacency does not inadvertently exclude potential contributing land base. Re-evaluations should consider changes in construction technology, changes in government policy, changes in wood values and changes in harvest systems.

During the projection phase of access development the entire transportation infrastructure should be evaluated. This evaluation should include all considerations for how the raw materials will be delivered to the processing facilities. This will involve cost – benefit analysis of different combinations of wood gathering points and the transportation logistics[9] associated with each of these points. The cost of a new wood gathering point will have to be weighed against the potential savings associated with reduced trucking and barging costs (for example). How these decisions are evaluated in expansive areas such as the coast of British Columbia will have an impact on economic operability.

Harvest System Assignment:

Once the transportation infrastructure has been evaluated and projected on the land base to the fullest extent possible, harvest system assignment is required for each forested stand

[9] Supply chain management or transportation logistics is a field of expertise requiring specialized knowledge of transportation systems and technology and may warrant the enlisting of such professionals to evaluate certain circumstances.

on the land base. Harvest system assignment should not be influenced by perceptions regarding marginal wood/stand value at this time.

It is important to consider the local practicality of harvest systems. While it may be physically possible to harvest any stand given the present technology, the available technology must be considered during the time frames in which the strategic level planning is to occur. Harvest system assignment should consider the harvest methods typical to the plan area. For example, if the ground based harvest systems in a planning area are limited to grapple yarders and hoe-forwarding the assignment of long line tower systems would be inappropriate unless concrete plans are in place by license holders to acquire and employ these systems in an economically feasible manner.

Harvest system assignment can be completed via an automated GIS exercise. Assigning harvest systems using GIS overlays requires that assumptions be applied regarding "limits" to both conventional and alternative harvest systems. Conventional harvest systems include all ground and cable based operations while alternative systems generally refer to those systems involving helicopter yarding. The assignment of harvest system should obviously default to the least expensive option that is practical.

Alternative harvest system limits should begin where conventional system limits end. Alternative harvest system assignment should be predicated by system knowledge and feasibility based on the projected road network.

4.3 Value Modeling

Value modeling is the task of assigning an average timber value (usually expressed as $/m^3) to each stand (or portion of a stand) in the inventory. The accuracy of the value model is highly dependant on the accuracy of the inventory data and the accuracy of the estimates of log product values. Value is often determined based on anticipated product mix (i.e. log grades) expected from a given set of stand attributes. When we discuss value in the context of determining economic operability we limit our attention to the first sale of the raw material (i.e. logs). Demand for subsequent secondary and tertiary products will dictate price for the raw materials based on the markets willingness to pay for the final product and the demand for the raw material associated with production. Value will be firmly linked to final use objectives and the value added during all phases of manufacturing.

Log Grade Predictions:

To assign value to stands, inventory attributes must be used to identify species mixes and predict grade (product) distributions. Options to complete this task are:

1. 'Tree lists' or detailed stand/stock tables for each stand can be created using links between inventory attributes and plot data or cruise data. Algorithms are used to link inventory stands with the most similar 'real' stands in the dataset and then assign attributes to the inventory polygon. This virtual stand can then be bucked into logs using bucking algorithms that provide merchantable volumes by log type/grade and species. A number of consultants around the province have developed algorithms to do this but the limiting factor is typically a lack of useable datasets that link stand structure to inventory attributes.
2. Harvest grade distributions can be predicted directly for each inventory polygons using cruise data or billing history records maintained in the Harvest Billing System

(HBS). This is a similar process to above where harvest volumes/grades are linked with inventory attributes and then grade distributions are predicted for all inventory polygons using algorithms or statistical analysis. Where sufficient relevant data is available HBS records will likely provide more accurate estimates of expectation based on past observation. Cruise grade estimates are based on statistical calculation and have little opportunity to address actual wood quality.

3. Expert opinion can be used to estimate grade profiles. Operational staff can be used to define general relationships between stand attributes and log grade outcomes based on local knowledge and experience.

One of the many issues complicating this task is the distinction between old growth and second growth stands and mixed stands. Old growth stands[10] typically have a wider range of grade assignments because of the greater variability in wood quality due to age. Second growth stands in contrast typically have a narrower and therefore more predictable range of quality. Therefore, it may be an option to use cruise grades for second growth and HBS data for old growth if complete data is not available.

The complexity in estimating stand quality is frustrated by mixed wood situations. Mixed wood cutting authority is not classified as second growth unless 80% of the coniferous volume is second growth. Second growth stands are typically of lower value due to wood quality and wood property issues. Meanwhile old growth stands may contain higher value stems. Discretion is required to determine which second growth stands this analysis should be applied to. Generally speaking all managed second growth stands should be assumed to be operable, and therefore not require evaluation. However, there may be instances where unmanaged second growth stands may be excluded on the basis of an economic operability analysis.

Table 2 lists typical attributes required to populate a value model. The accuracy of these attributes is directly linked to the validity of the wood quality attributes assigned to each stand. Therefore, it is essential that this data be current and relevant.

Table 2. Stand Quality Attribute Inputs

Cost Attribute	Units/Reference Measure
Species 1	Inventory
Species 1 %	Percentage
Species 2	Inventory
Species 2 %	Percentage
Species 3	Inventory
Species 3 %	Percentage
Species 4	Inventory
Species 4 %	Percentage
Species 5	Inventory
Species 5 %	Percentage
Species 6	Inventory

[10] Old growth is defined in the Coast Appraisal Manual as older than 140 years.

Cost Attribute	Units/Reference Measure
Species 6 %	Percentage
Age	years
Height	meters
Crown Closure	numeric
Site Index	meters
Volume estimate	m^3
Wood Quality	Grade
Stand Type	Old-growth/ Second-growth

Value is very dependant on final use objectives and value added. Final use objectives will vary between licensees and processors dependant on the nature of the organization and the business process involved. Business process will include all aspects of an organization's efficiency, innovation and marketing abilities.

Assigning Stand Values / Market Considerations:

Market forces are particularly unpredictable so much so that entire professions are dedicated to the forecasting and explanation of market behavior. Therefore, market forecasting is a separate topic outside the scope of an operability assessment. However, persons undertaking operability mapping exercise must understand the basic pressures on the forest products industry. Understanding the 'pressures' will allow informed decisions to be made regarding market forces.

Stand values are simply the product of volumes by log grade and price by grade. This value is then simplified to an average value ($/m^3) for the stand as a whole so that it can be integrated with the rest of the economic model. The selection of market values for various log grades is a critical decision and has huge implications on the results of the assessment. If the intent is to identify a land base for long term strategic planning, then market values should be selected to reflect the variation that can be expected over the planning time frame. Historical market price data are one source for this data. Where available, localized data can be obtained from company records or, alternatively, more generalized appraisal values for various log grades can be used. Some sources for this information include:

1. Vancouver Log Market Prices
2. Coast Forest Log Reports: Coast Forest Products Association, Vancouver, BC
3. MOFR Coast selling price system: http://www.for.gov.bc.ca/hva/timberp/amv.htm

As suggested earlier, there is merit in defining the range of market values that could occur going forward (or have occurred in the last cycle) so that several runs can be completed and the sensitivity of the operable land base can be evaluated. The probability that a stand will be economically operable at some point during the life span of the current planning horizon must be considered. Conceptually, stands with a low probability should likely be considered inoperable, while stands with a high probability should be considered operable.

Earlier in this document, the concept of the core operable area (operable in all anticipated market conditions) and the marginal operable area (operable only in some market conditions) was introduced. These would be generated using low and high market values for various log products, in effect testing the sensitivity to price variation. Selection of a median market condition is typically used to generate an operable land base for TSR as it is neither optimistic nor pessimistic.

The economic operability of marginal stands is highly dependant on assigned value. Therefore, the value equation should be flexible and be capable of addressing changes ranging from utilization standards to in block retention requirements (e.g.. for ecosystem based management). Changes to utilization standards may have substantial impacts on marginal stands whose economic operability is very close to the minimum revenue requirements. Similarly, requirements for in block retention percentages can have the same effect. In a situation where retention requirements are increased the net effect is that the harvestable volume will decrease. Value equations or models must be able to address these changes and identify which area is at risk from this sort of change.

4.4 Establishing Threshold Values

Once net values have been defined for all stands, a relative ranking of value across the landscape is available and can be used for context information in the development of a final operability line. However, if the stand level economic assessment results are to be used as the final definition of operability, a net value threshold needs to be established.

Defining a threshold value infers that the calculated net values not only show relative differences across the land base but that they reflect absolute net values for each stand. For example, if a stand is assessed to have a net value of negative $10, it would be assumed that a $\$10/m^3$ loss would result from logging that stand. This use of the data requires a significantly higher degree of accuracy to be assumed in comparison to an assessment of the at relative value relationships between stands. However, once a final set of market and cost assumptions have been established, it is necessary to assume that this represents the best available information from which to make decisions - and thus a threshold needs to be defined. The obvious threshold value is a net value of zero – a stand must have be at least breakeven position to be considered operable. However, the selection of a threshold value is dependant on how well the value and cost modeling is able to represent reality. Issues such as the following may cause the threshold value to shift:

1. The type of data used (i.e. localized operational vs appraisal averages). The use of less accurate data such as appraisal averages may suggest that a different (higher or lower) threshold value be used to reflect local conditions.

2. The policy framework currently in use (i.e. current stumpage system can subsidize marginal stands). If cutblock blending is used to make marginal stands economic then the threshold value should fall somewhere below zero. How far will depend on how much risk users of the data are willing to assume that the policy framework continues and licensees utilize it. This issue is discussed more in the next section.

3. The cost/value assumptions used in the analysis are very optimistic or pessimistic ones. If low market prices are used, the probability of negative net value stand being economic is higher than if high market prices were used. Ideally, this decision should be made at the value assignment stage – set a reasonable market value and then leave this consideration out of the threshold decision.

If the data inputs to the economic model are not accurately reflecting on-the-ground economics in an absolute way – there is likely a need for some kind of calibration process. If the relative values across the land base are believed to be reflective of the situation, then it is simply a matter of using known marginal stand values to define a reasonable threshold. This could be done by setting the operability threshold based on the assessed value of a known marginal stand.

4.5 Stumpage Issues

Stumpage is a cost factor that has been debated for inclusion in stand level economic assessments in an effort to fully recognize all costs that influence economic viability. Stumpage may or may not be included in an economic operability assessment. Unfortunately, it is not possible to predict what stumpage will be on a given stand at any point in time over the strategic planning horizon. The objective of an economic operability assessment should not be to focus on determining stumpage. The objective is to identify a operable land base based on expectation, past experience and some speculation. How conservative or aggressive that speculation is will depend on the risk tolerance of the province.

These assessments really boil down to assessing whether marginal stands fall in or out of the operable land base. Strongly positive stands are operable, strongly negative stands are inoperable, and the marginal ones are where the operability question lies.

So if we are primarily concerned about the stands on the economic margin, two main points emerge:

1. Conceptually, stumpage is a sliding scale tax or royalty that is collected by the crown. The higher the value index, the more stumpage is paid. If a stand has a negative value index, then it is subject only to minimum stumpage ($0.25/m3). Thus, stands on the margins (i.e. breakeven net values or worse) would have almost no stumpage applied if they were assessed on a block by block basis.
2. Actual stumpage values are calculated using cut block blending. Cut block blending effectively lowers the value index (and therefore stumpage payments) for cutting permits where lower value stands (potentially negative value ones) are combined with higher value stands. This blending acts to subsidize the harvest of marginal stands and can act as a positive influence instead of a cost. An example of this situation would be the inclusion of a heli-logging block containing good wood (negative net value on its own), with a series of cable/conventional blocks (large positive values) in a cutting permit. The blending brings down the stumpage bill on the positive blocks and makes the package 'economic'. In this case, the heli-logging block would never be logged on its own but the blending of blocks made it economic (a positive influence instead of a cost).

Since stand level economic operability assessments are primarily focused on the contribution of marginal stands, inclusion of stumpage as a cost in these assessments would not be appropriate.

The cutting authority system that the forest industry currently operates under is one which allows higher value stands to effectively subsidize lower value stands. This system is designed to ensure that the maximum value is realized from the contributing forest landbase to encourage a vigorous, efficient and world competitive timber processing industry in the province.

Stumpage should be viewed as a sliding scale tax or royalty paid to the crown for the right to harvest timber. The stumpage system is designed to allow higher value resources to offset some of the cost of development of lower value resources which may otherwise not be developed on their own. Once a cutting authority has been issued and the stumpage rate has been assessed based on the area in the permit it is inappropriate to then evaluate any individual setting in that permit individually because the rate established in the cutting authority is the blended rate for the entire permit.

5 Recommendations

Effort in operability mapping exercises should be focused upon elements which will yield the greatest improvement in certainty for the least expenditure. For example it is possible to invest heavily in a stumpage forecasting model that in turn may do very little to increase the level of confidence in the projected stand or watershed values. Emphasis should be on the tangible such as the inventory data which is used to populate the value equations and the market statistics which are used to populate the cost and value equations.

The size of the contributing land base used in timber supply analysis can have an enormous effect on the economic benefits derived from the forest, the forest industry and related enterprise. The land base which remains operable at all points during the business cycle can be identified and referred to as the core operable area. That portion of the land base which moves in and out of preference during the business cycle is the area which needs to be scrutinized. This marginal land base represents significant opportunity for the province and the forest industry if managed correctly. For instance, an upward trend in prices, relative to past market cycles, may present an opportunity to harvest in this portion of the land base. Market variation impacting value and cost must be incorporated into economic operability assessments to ensure that the most forward looking landbase is used in TSR.

Economic operability assessments ultimately require that subjective judgments be made regarding where the economic operability threshold lies. This threshold defines the point where stands are included or excluded. In selecting a threshold marginal value in an economic operability study, the objective is to define a land base which is neither too optimistic nor too pessimistic for use in timber supply forecasting. Including measures of statistical variance observed in the preceding cycle will make this decision less subjective.

The reliability of the above decision is dependant on three main inputs (costs, values and market forces) and sound professional judgment (affirmed and supported by sufficient analytical review). These inputs are like the legs on a stool; if one is weak or absent the results of any assessment made on them is unstable and unreliable. In addition to sound judgment, accurate and reliable cost and value data are required. Judgment determines the validity of cost and value metrics. However, without an accurate and reliable forest cover inventory that captures the nuances of the land base the validity of the other inputs is lost. Reliable economic operability evaluations cannot be made using an inventory which does not accurately reflect the land base.

5.1 Use in Decision Making

The Timber Harvesting Land base is a dynamic inventory of stands which contribute to timber supply for the province. This land base is dynamic in the sense that market forces will cause it to expand and contract with the variability in market value and associated supply and demand. This land base should be viewed as consisting of a core operable land base which is always operable and always contributing. In addition there is a considerable amount of forested land base which may contribute to timber supply at certain times during the cyclical variation of log values (marginally operable land base). Stand level economic operability assessments should be designed to provide insight into this range of economic variability for use in TSR and land use planning.

Economic operability models are a powerful tool in the forest planners' tool kit. Provided that the limitations are understood, these models can be used to support the planning process for which they are intended. In order to be most effective, economic operability models should be used in conjunction with other planning tools to identify the land base which will contribute to TSR determinations. This process should be revisited with the same frequency as the TSR or as necessary to support other forest management planning initiatives.

The dynamic nature of the operable land base is readily illustrated by a spatially explicit economic operability model. Therefore, this type of model is well positioned to be used to identify the opportunistic portion of the land base which is likely to contribute to timber supply at some point. This area should be identified in forest inventory data sets as area "of interest" such that the opportunity can be then inserted into other land use planning processes to recognize the potential and to mitigate the long term impacts of land use decisions. These opportunistic 'isotherms' may also be used to support partitioned annual allowable cut determinations to both preserve the land base and foster innovation and investment.

The timber harvesting land base identified in an economic downturn will be very different from one identified in a booming economy. It should be viewed as critical to prevent short-sighted decisions made during an economic downturn or recession from removing future long-term timber supply opportunity. Identifying and measuring the contributing land base in this manner will ensure that full opportunity cost accounting is possible and evident to support and report on land use planning initiatives.

Using economic operability models to identify the land base in this manner should mitigate conflict between competing resource use values and land use planning initiatives.

Hazard of applying the average:

When building cost and value equations it is important to capture market variation. Costs will vary between operators, often dramatically and value will fluctuate on a daily basis. Therefore, there is a real hazard associated with applying mean or median values (associated with a particular month or even a year) in assessments that will be then used to evaluate opportunity over a strategic planning or business cycle (i.e. the 5 year TSR schedule). While an average value may be a reasonable measure of what might be expected all of the variation that went into that value is lost if the statistical variance is not included in the assessment. High value stands will typically remain positive when measured against average performance meanwhile stands at or near the margin will be susceptible to erroneous exclusion.

Statistical variance of all data inputs in the cost and value equations should be measured such that one or two standard deviations of the data (assuming the distributions are normal) can then be incorporated into the models. Examining the data in this manner will remove some of the subjectiveness in the decision regarding where the economic threshold lies. The cost equation should capture the variation of cost over a predetermined period. Value should then be measured over the same period. This period should be similar to the period length to which the results of the analysis will apply. The length of the period and the number of standard deviations to capture is a separate topic for debate on a case specific basis. Ideally a moving average with statistically supported confidence intervals attached would define the land base based on up to the moment actual cost and value trends to then identify the appropriate land base for timber supply calculation. Since this is not a practical alternative forest planners must choose a representative sample data set (typically the preceding planning period and regularly (on the planning cycle) reevaluate economic operability for the next planning interval.

Typically cost data variation will not be as substantial as that for value. Regardless the variation is present in each of the data elements and cannot be overlooked. Recent work completed in the Kingcome Timber Supply Area[11] demonstrated how sensitive the economically operable land base is to different market conditions, illustrating the differences between the land base projected with 1995 high market prices and 2003 low market prices. This variation needs to be addressed in all economic operability assessments. The most easily implemented process (one that removes conjecture) to measure this is statistical variance of the inputs.

Data sources:

Ideally cost data will be locally relevant and readily available. In situations where this is not the case, alternative sources will need to be evaluated. The annual industry cost survey is one source for this information. Improving upon these data may require that more data points be added. These additional points would be targeted to ensure cost averages are reflective of local experience. For example if BCTS is supposed set the pricing thresholds for the market pricing system then the cost survey must ensure that sufficient data 'points' are collected from this operating area to ensure that representative data is then used in economic operability assessments.

The Harvest Billing System (HBS) is another source of information that may be used to assemble harvest statistics that represent the plan area. Specialized reports may have to be developed to extract this information relative to the plan area of interest. However, provided that the data can be made available for the assessment project this filtering is not overly complex. The complex part of this process is in determining what data should be included or exclude to arrive at a representative sample.

Presently no reports are available from the Revenue Branch of the Ministry of Forests and Range[12] which illustrate or capture variation in value. Economic operability assessments should pursue this data such that the statistical variation over multiple periods can be examined and the variance observed incorporated into the model equations. Spot log prices from the Vancouver log market will illustrate the variability in value and illustrate how the use of average values can lead to overly conservative land base estimates.

5.2 Key Recommendations

1. Complete stand level economic assessments only where reasonable inventory data exists. If inventory information is poor, consider alternative approaches to operability mapping (i.e. site level total chance planning).

[11] Economic Operability Assessment of the Kingcome Timber Supply Area, Timberline Forest Inventory Consultants Ltd., Undated

[12] Brent Sisco, Senior Timber Pricing Accountant, MOFR, personal communication.

2. Use local, operational data to derive costs and stand values where possible. Rely on appraisal information where this is not possible or too cost prohibitive.
3. A major benefit to stand level economic assessments is their ability to quickly run sensitivity analyses and explore the effects of different cost and/or market conditions. Use this benefit to define a core operable land base (always operable under anticipated economic conditions) and a marginally operable land base (occasionally operable under anticipated economic conditions). The relative size of the marginal land base should indicate the sensitivity of the THLB to market conditions.
4. Ensure that cost and value assumptions anticipate change and are reflective of anticipated future costs and market values. This is typically done using historical fluctuations as guide. Consider using statistical variances as a means to avoid simply applying average values.
5. Identify the marginally operable land base for use in other planning processes (LRMP's, OGMAs, etc) in order to minimize impacts to timber supply and economic returns in the face of retention requirements.
6. Do not include stumpage as a cost in stand level economic assessments – it is not relevant for stands on the economic margin. In fact, it has the potential to subsidize marginal stands into the operable land base. Inclusion of stumpage will shrink the economically operable landbase.
7. Follow up stand level economic assessments with a qualitative assessment and expert opinion of operable and inoperable areas – using the objective economic assessment results to provide context. This will improve the end product by better addressing stand level neighborhood issues that are not well addressed in the assessment and will ensure local knowledge is integrated into the final operable area. This second phase would also reduce the importance of defining a threshold value for operability.
8. If the stand level economic operability results are going to be used to define the operable land base alone, consider a calibration exercise to define the threshold value. Known marginal stands (both inoperable and operable) should be used to define a threshold value that can be used to extrapolate to the remainder of the land base.
9. Revisit economic operability assumptions prior to each timber supply review process and update to reflect new or better data.

6 Appendix 1: Common Cost Groupings

Financial State of the Forest Industry and Delivered Wood Cost Drivers

April 1997

Tree to truck

All costs associated with falling, bucking, yarding and loading timber from the point immediately after the pre-work conference to immediately before the logs are hauled. This category does not include the costs of salaried logging supervisors which should be included within *Forest management and engineering* below.

Hauling

All costs associated with hauling logs from the logging site to the mill log yard or an intermediate dump site such as a rail reload point or a water dump site for intermediate water transport by boom or barge.

Dump, sort, boom and rehaul

All costs of intermediate rail or water transport, including log dewatering costs for intermediate water transport but excluding log yard dumping or sorting costs.

Forest regeneration

All costs associated with bringing a logged site back to free growing status, including site preparation, planting, brushing and weeding, fill planting and surveys (together, "basic silviculture"). This category does not include "intensive" or Incremental silviculture techniques applied to free growing stands.

Road expenses

All costs related to road and bridge construction, maintenance and deactivation for both expensed and capital roads, but excluding road design and layout costs and supervision which should be included within *Forest management and engineering* below.

Forest management and engineering

All costs associated with cruising, forest planning (involvement in higher level and strategic planning and preparation of operational plans), forest protection, supervision of road construction and logging, road and cutblock layout, divisional due diligence and the divisional/operation share of head office forest management expense.

Other overhead

All remaining camp overhead, including administrative support wages/salaries and benefits, scaling expense, residue and waste expense, vehicle expense for logging administrative staff, licences, fees, insurance, taxes, leases annual rent and depreciation of administrative buildings.