

East Kootenay Timber Merchantability Analysis

June 2003 Update –Version 2.1
File: 13270-20 Merchantability Analysis

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Acknowledgements:

The original version 1.0 of this project was supported by the insights and collaboration of timber staff in the Cranbrook Forest District, including Gary Dolynchuk, Timber Officer, Bob Couperus, Timber Technician, and Paul Cohen, Cruising and Valuation Technician. Licensee forest planners involved with Forest Development Plan preparation, including Lloyd Havens, Ken Streloff, Brian Dureski, and Joe Tress of Tembec Industries Inc.; Randy Byford of Galloway Lumber Co.; and Steve Byford of the Ministry of Forests Small Business Forest Enterprise Program assisted with model review and critique. Peter Davidson, Forest Ecosystem Specialist also reviewed the model.

Interim GIS analysis and presentation products were prepared by Rex Durell, GIS Technician, Cranbrook Forest District. Costs and values were originally derived from the Ministry of Forests Sept., 2000 appraisal manual. Data preparation, analysis and product outputs were conducted by Reg Davis of Interior Reforestation Ltd. Funding was provided by Ministry of Forests, Small Business Forest Enterprise Program, Galloway Lumber Co. Ltd, Tembec Inc. and Forest Renewal B.C. The model was since applied to planning data files by Eric Valdal and Russ Hendry of Ministry of Sustainable Resource Management. Russ Hendry has conducted model tests on the Southern Rockies Management Plan area to ensure that the model can be interpreted and applied correctly and that it functions as intended.

A proposal by Barry Benson of Tembec Industries Inc. to apply the model to the Invermere TSA in early 2003 allowed for an update (labelled Version 2.1) to correspond to the Jan. 2003 Interior Appraisal Manual. This update work was sponsored by Barry Benson and Doug Braybrook of Tembec Canal Flats, and supported by the Forest Investment Account.

Key changes from version 1.0 to 2.1 are as follows:

- Adjusted to reflect mean East Kootenay costs and values rather than Cranbrook Forest District
- Costs and values updated to the Jan. 1, 2003 Interior Appraisal Manual a point considered reasonably representative of average market cycle conditions.
- Silviculture costs were significantly revised in the appraisal manual and these changes are reflected in the model.
- Documentation of assumptions in the model document is improved.

Introduction:**Goal:**

To model and map timber merchantability in the East Kootenay to support cost effective and sustainable management of the timber harvesting land base, and identify timber which can be reserved for ecosystem values with the least economic impact.

Background:

Determining forest merchantability is complementary to many mandated forest management activities required by legislation. For example:

- ***Ministry of Forests Act:* “manage, protect and conserve the forest and range resources of the Crown, having regard to the immediate and long term economic and social benefits they may confer on the Province.”**
- ***Forest Practices Code of B.C. Act:* “managing forests to meet present needs without compromising the needs of future generations“.**
- ***Forest Act:* “The Chief Forester must assess the land in British Columbia for its potential for growing trees continuously” and consider a variety of factors on ability of land to support timber production when setting the AAC per Section 8.**

Merchantability and Operability were **key issues in Timber Supply Review 2** for the Cranbrook TSA. Quoting from the Chief Forester's rationale, Dec. 2000, pages 12, 13:

"I expect to see more consistent harvesting of these higher elevation stands if they are to continue to contribute to the timber supply in the future" and "Before the next determination, I urge district staff and licensees to review **operability** and refine the mapping in consultation with local stakeholders."

And on page 53 (Implementation): "I recommend that district staff:

- evaluate and implement strategies for **harvesting of difficult terrain**, if the areas are to continue to contribute to timber supply;
- review previously excluded forest types, which have been included in the current timber harvesting land base. In particular examine the **merchantability**, terrain, location and **economic factors** that might limit harvesting of these types;"

Chief Forester Larry Pedersen was concerned that uncertainty and lack of performance in the lower merchantability (marginal operability) types could seriously affect timber supply. This merchantability analysis is designed to calculate and quantify timber economic potential, and provide the basis to strategically manage utilization of the timber profile to support the AAC. Classification of merchantability potential also allows for strategic investment decisions in stand rehabilitation, incremental silviculture, and backlog reforestation.

Project Objectives:

1. To apply **merchantability criteria** that can be evaluated and adjusted as technology or economics change; and can be compared to other regions of the Province.
2. To work with easily obtainable **cost and value recovery data** that is already being collected and summarized. This will allow for regular model updates.
3. To quantify the change to, or sensitivity of, the **timber harvesting land base** as merchantability criteria are altered, and highlight areas for review of the **operability line**.
4. To define **economic strata of forest stands** that allow for management or representation of the timber harvest profile in operational plans showing what range and proportion of strata are being utilized.
5. To provide a tool for **managing the assembly of blocks into cutting permits** that will promote full utilization of the economically harvestable profile.
6. To provide a tool to help minimize impacts on the forest industry by **recruiting for environmental needs** with preference for the least merchantable stands with required environmental characteristics.
7. To provide a tool for assessing the **equity of operating areas** between licensees.

Key Assumptions:

All timber is potentially physically operable with technology available today. For example, theoretically a helicopter could be used to remove a single tree from a remote, steep, sensitive site, if one was prepared to spend enough money to do so. Merchantability is a tool for describing the relative economics of timber harvesting opportunities throughout the forested land base.

For modelling convenience, **Interior Appraisal Manual factors, costs and values** are used. To simplify modeling **average weighted costs and prices** are used to estimate base values and then factors are used to adjust for species, stocking, volume or other variables.

Data available for this analysis is limited to **TRIM** and **forest cover inventory** information supplemented by certain additional available data such as cycle times, and terrain sensitivity. Stand product recovery values are derived from readily available variables in the Ministry of Forests **Interior Appraisal Manual** using **Ministry of Forests yield functions and loss factors**.

When many factors are considered in estimating relative stand values, **imprecision** in any one factor will not seriously impact the reliability of the overall value index determination.

For the primary model, all immature stands are projected to **culmination age** to assess their economic potential. All stands older than culmination age are evaluated according to their current characteristics.

Model **options** to account for Old Growth Site Index adjustment of decadent stands, and to consider site potential on areas where a forest health factor or previous partial harvests have degraded the current stand, can be run to determine prime areas for rehabilitation.

It should be noted that this model is designed to approximate a stand's value index which is defined as the selling price for lumber and chips less the operating costs required to produce these products. This value is the value of the crop to the landholder which is the provincial Crown. This value is primarily captured by the Crown as **stumpage** and is not an operating profit for the forest company. The operating profit for a forest company in a good market is a fraction of this amount, and in a poor market an operating loss is generated. Appraisals are intended to reflect a rolling average value and are more useful for comparing **relative merchantability** of various stands than determining a specific stand's profit margin.

As stated in the Interior Appraisal Manual:

The following stumpage parameter values are effective January 1, 2003:	
Interior Composite Index	183.2
Interior Target Rate	13.93
Interior Mean Value Index	17.09
Interior Base Rate	14.83

Prepared by Revenue Branch, Ministry of Forests (December 2002)

For example: Assume a stand has a value index of \$20.00 per cubic meter. It would generate an **indicated stumpage** of: $ISR = IBR + (VI - IMVI)$ or $14.83 + (20.00 - 17.09) = \$17.74/m^3$. The \$20.00 value is reduced by \$17.74 in stumpage to return a profit of \$2.26 on a total operating cost of some \$120.00/m³ or about 2%.

Section 1 Determining Stand Product Values

1A) Determination of Total Value Recovery per m3 for mean species profile.

For this analysis: Stand Product Values = function of Site Index, Species, Stocking and Age.

Stand product value is dependent on the average height and diameter at harvest age which affect operating costs (which will be dealt with below) and lumber and chip recovery in the mill. These are all related to the **site index** of forest land, allowing for all sites to be ranked regardless of current stand age. Site index in the East Kootenay varies from a high of about 30 to low sites with site index less than 8. Productivity is estimated using the mean East Kootenay species mix modelled using VDYP (natural stand yields). Approximate mean species mix for the East Kootenay is: 45% Pl, 21% Fd, 13% Lw, 11% Se, 8% Bl, 2% Py based on weighting Cranbrook and Invermere TSA species profiles. Adjustment for site specific leading species is provided in table 2.

Table 1 Total Stand Value Recovery Based On Site Index. (Allow Special Site Index to Override Inventory Site Index wherever available in the data.) Volumes are less decay, waste, breakage per VDYP.

Site Index Range: (SI curve)	Cul min atio n Age VD YP	MAI M3/h a/yr	Vol./ ha M3	Ht. M	Quad. Mean Diam. cm	Appro x. Avg. Net Tree vol. M3	Lumb. Rec. Factor MBM/m3 (+ mean addon of 74 bdft/m3)	Chip Rec. Factor BDU/m3	Mean Lumber Value \$/m3 (@\$430/M BM)	Mean Chip Value \$/m3 (@\$102/B DU)	Total Value Recovery \$ per m3
<8 (7)	161	0.64	98	14.1	19.6	0.14	0.214	0.189	\$82.50	\$12.40	\$94.89
8-9.9 (8)	152	0.79	114	15.2	20.5	0.17	0.228	0.177	\$87.89	\$11.56	\$99.46
10-11.9 (10)	138	1.10	144	17.3	22.0	0.22	0.248	0.158	\$95.60	\$10.37	\$105.98
12-13.9 (12)	130	1.42	175	19.3	23.3	0.27	0.269	0.139	\$103.70	\$9.12	\$112.82
14-15.9 (14)	115	1.74	191	20.7	23.7	0.30	0.282	0.127	\$108.71	\$8.34	\$117.06
16-17.9 (16)	99	2.11	200	21.7	23.5	0.31	0.290	0.120	\$111.80	\$7.87	\$119.66
18-19.9 (18)	87	2.51	210	22.7	23.5	0.32	0.296	0.115	\$114.11	\$7.51	\$121.62
20-21.9 (20)	78	2.95	222	23.5	23.6	0.34	0.298	0.113	\$114.88	\$7.39	\$122.27
22-23.9 (22)	71	3.39	233	24.7	23.4	0.35	0.305	0.106	\$117.58	\$6.97	\$124.55
24-25.9 (24)	66	3.86	247	25.8	23.6	0.37	0.311	0.101	\$119.89	\$6.62	\$126.51
26-27.9 (26)	63	4.10	251	27.2	23.5	0.39	0.319	0.094	\$122.97	\$6.14	\$129.11
28-29.9 (28)	63	4.10	251	29.3	23.5	0.42	0.326	0.087	\$125.67	\$5.72	\$131.40
30+ (28)	63	4.10	251	29.3	23.5	0.42	0.326	0.087	\$125.67	\$5.72	\$131.40

- LRFs are derived from TIPSYS runs for Pl, Fd, 1600 natural trees/ha, for each site index class at the VDYP culm. age.
- A weighted average recovery add-on of 76 bdft/m3 per appraisal manual has been added to account for improved mill technology.
- Chip recovery factors are derived using the Interior Appraisal Manual formula of $(422 - (LRF \times 1000)) \times \text{mean weighted species chip recovery factor of } 0.00091 \text{ BDU/MBM Equivalent}$.
- Prices are as in effect as of Jan. 1, 2003 for southern interior.
- Net tree volume is approximated to be $Ht. \times (DBH/2)^2 \times \pi \times 0.33$

1B) Adjusting Value Recovery to account for Leading Species variation.

Stand product value is dependent on species as lumber and chip values vary by species. To simplify modelling only the leading species is used to adjust product values. Using appraisal manual species values the following combined factor is derived.

Table 2 Leading Species Effect On Total Value Recovery

Leading Species	Inventory Type Groups	Relative Value Based on AMVs (mean) \$/MFBM	Relative Value of Chips \$/BDU	Combined Value per m3 (290 bdf t plus 0.12 BDU)	Adjustment To Mean Value
Weighted Mean		385.50	65.00	119.65	N/A
Spruce	21-26	387.00	65.50	120.09	1.00
Larch	33-34	396.00	65.50	122.70	1.03
White pine	27	478.00	65.50	146.48	1.22
Douglas-fir	1-8	396.00	65.50	122.70	1.03
Lodgepole pine	28-31	381.00	65.50	118.35	0.99
Western red cedar	9-11	751.00	10.00	218.99	1.83
Western hemlock	12-17	340.00	65.50	106.46	0.88
Ponderosa pine	32	392.00	65.50	121.54	1.02
Subalpine fir	18-20	362.50	65.50	112.99	0.94
Deciduous*	35-42	200.00	10.00	59.20	0.49

Combined affect calculated based on site index 16 average weighted stand value per Table 1.

1C) Adjusting Value Recovery to account for Tree Stocking variation.

Tree stocking affects the size and volume of timber on a site, and thus the product recovery. Three indicators of stocking are possible, but only partially inventoried in existing forest cover inventory data. Where they are present, they can be ranked most desirable to least desirable as follows:

Table 3 Estimated Stocking Affect On Total Value Recovery

Stocking Description	Stocking Class	Tree Density (Where Available)	Crown Closure	Estimated Stocking Factor Impact on Average Stand Value
Immature Full Stocking (<age 100)	0	< 5000 stems per ha	All	1.00
Age 41-60 or Age 61-80 or Age 80+	0	< 5000 stems per ha	And <25% And 25-34% And 35- 44 %	0.90 Slightly knotty
Age 61-80 or Age 80+	0	< 5000 stems per ha	And <25% And 25-34%	0.80 Knotty, slightly tapered
Age 80+	0	< 5000 stems per ha	And <25%	0.70 Very knotty, tapered
Mature Full stocking with Good piece size	1, 3 or R	< 5000 stems per ha	> 45 %	1.00
Mature Slightly Understocked with Good piece size	1, 3 or R	< 5000 stems per ha	35- 44 %	0.90 Slightly knotty
Mature Understocked with Good piece size	1, 3 or R	< 5000 stems per ha	25- 34 %	0.80 Knotty, slightly tapered
Mature Severely Understocked with Good piece size	1, 3 or R	< 5000 stems per ha	<25 %	0.70 Very knotty, tapered
Mature Severely Understocked	2 or 4	< 5000 stems per ha	All	0.65 Very knotty, tapered, small
Overstocked Postwood	All	5,000 to 10,000 stems per hectare	All	0.50 Very small
Repressed	All	>10,000 stems per hectare	All	0.25 Excessively small

1D) Adjusting Value Recovery For Stand Age

Stand age affects the expected recovery and value of the timber in a stand. It is assumed that immature stands will be left to mature to a minimum harvest age (near culmination) that generates an acceptable standard value recovery. However older stands first increase in piece size and then begin to experience significant decay and other defects. Therefore age is estimated to impact stand product values with increasing lumber recovery factors and simultaneously decline according to the Provincial loss factors. For all stands above culmination age as indicated in the table below, the age affect on value recovery due to increasing piece size and lumber recovery can be approximated as follows:

Table 4(a) Adjusting for age affect on piece size and lumber recovery.

Site Index Range: (SI curve)	VDYP Culmination Age	Minimum Age For Adjustment to Apply	Piece Size Age Effect on Value recovery	Example Factor At Age 200
<8 (7)	161	162+	(Age – 161) x \$0.11/m3/year	+\$4.29/m3
8-9.9 (8)	152	153+	(Age – 152) x \$0.11/m3/year	+\$5.28/m3
10-11.9 (10)	138	139+	(Age – 138) x \$0.11/m3/year	+\$6.82/m3
12-13.9 (12)	130	131+	(Age – 130) x \$0.11/m3/year	+\$7.70/m3
14-15.9 (14)	115	116+	(Age – 115) x \$0.11/m3/year	+\$9.35/m3
16-17.9 (16)	99	100+	(Age – 99) x \$0.11/m3/year	+\$11.11/m3
18-19.9 (18)	87	88+	(Age – 87) x \$0.11/m3/year	+\$12.43/m3
20-21.9 (20)	78	79+	(Age – 78) x \$0.11/m3/year	+\$13.42/m3
22-23.9 (22)	71	72+	(Age – 71) x \$0.11/m3/year	+\$14.19/m3
24-25.9 (24)	66	67+	(Age – 66) x \$0.11/m3/year	+\$14.74/m3
26-27.9 (26)	63	64+	(Age – 63) x \$0.11/m3/year	+\$15.07/m3
28-29.9 (28)	63	64+	(Age – 63) x \$0.11/m3/year	+\$15.07/m3
30+ (28)	63	64+	(Age – 63) x \$0.11/m3/year	+\$15.07/m3

Adjustment factor developed using mean site index 16 in TIPSy runs for Pl 60, Fd 40 mix (only local species available), calculate LRF and CRF at age 200 and determine difference at age 99. The calculated value difference is prorated over the 101 years to determine the annual value increment, in this case \$0.11/m3/year.

Table 4(b) Age Affect on Decay and Defect

Leading Species	Stand Age	Decay and Defect Impact On Value Recovery Factor
Deciduous	0-40	*0.92
	41+	*0.50
Pl Leading	0-80	*1.00
	81-120	*0.96
	121+	*0.89
Py Leading	0-80	*1.00
	81-120	*0.97
	121+	*0.95
Pa/Pw Leading	0-80	*1.00
	81-120	*0.96
	121+	*0.91
Fir Leading	0-80	*1.00
	81-120	*0.93
	121+	*0.93
Larch leading	0-80	*1.00
	81-120	*0.95
	121+	*0.89
Spruce Leading	0-80	*1.00

	81-120	*0.94
	121+	*0.92
Balsam Leading	0-80	*1.00
	81-120	*0.93
	121+	*0.69
Cedar Leading	0-80	*1.00
	81-120	*0.90
	121+	*0.59
Hemlock leading	0-80	*1.00
	81-120	*0.92
	121+	*0.82

Adjustments are derived from Provincial loss factor tables, and applied by leading species to simplify modelling. These volume factors are assumed to approximate value loss due to decay and defect.

1E) Determining Average Stand Product Value

Average stand product value is then computed as follows:

**ASPV= ((SI Based Product Value x Leading Species Factor x Stocking Factor) + Piece Size Affect)
x Decay and Defect Factor**

Average stand product value is a value per m3 of raw material in potential finished lumber and chips.

Step 2 Determining Operating Costs

Operating costs are all those costs involved with operating a forest tenure, building roads, harvesting wood, manufacturing products and reforestation of harvested areas.

Operating cost = function of slope, terrain, volume/ha, cycle time, species, stocking and age.

Varying slope conditions require different harvesting systems and affect harvest costs.

Slope classes (10%) are processed through GIS using 20 m TRIM contour mapping, filtered to approximately 1-2 ha minimum polygon size. (Variable filtering may use higher resolution on steep terrain $\geq 40\%$ (0.5ha) and lower resolution on gentle terrain $< 40\%$ (2ha))

- Ground skidding and mechanical harvesting/forwarding equipment is most economical on terrain less than 30% slope but can be used up to a little over 40% slope.
- Short yarding cable harvesting is most suitable on slopes below 65-70%.
- On slopes over 70% road density and cost to provide access increases dramatically favouring a move to long line (intermediate support) yarding, aerial (skyline) yarding, or aerial (helicopter) yarding.
- As slope exceeds 100% it becomes more dangerous, expensive and difficult to operate. On such slopes it is assumed that, due to slope stability, harvesting is restricted to partial cut helicopter logging.
- Therefore one can generalize that increasing slope increases road and trail density and/or cost, and the cost of the harvest system.

Using the Interior Appraisal Manual Jan, 1, 2003, the results of these slope related factors are depicted in the following tables:

2A) Determining Road Development Costs

Using diagrams and samples from forest development plans, estimates of road density per km² were developed to allow for estimation of road development costs per m³ of wood developed. According to the Interior Appraisal Manual, road costs are primarily a function of side slope.

Table 5 Road Development Costs

Slope	Estimated Km road per Km ² (20,000 m ³ wood volume)	Cost of road subgrade/ km	Road surfacing – Assume 10% of Roads \$/km	Total Road Cost/km	Total Road Cost / km ²	Cost of road / m ³ Assumes 200m ³ /ha
0-10	4.0	\$10189	\$1256	\$11445	45780	\$2.29
>10-20	4.4	\$11949	\$1256	\$13205	58102	\$2.91
>20-30	4.8	\$13709	\$1256	\$14965	71832	\$3.59
>30-40	5.2	\$15469	\$1256	\$16725	86970	\$4.35
>40-50	4.0	\$17229	\$1256	\$18485	73860	\$3.69
>50-60	4.4	\$18989	\$1256	\$20245	89078	\$4.45
>60-70	4.8	\$20749	\$1256	\$22005	105624	\$5.28
>70-80	1.0*	\$20749	\$1256	\$22005	22005	\$1.10
>80-90	1.0*	\$20749	\$1256	\$22005	22005	\$1.10
>90-100	1.0*	\$20749	\$1256	\$22005	22005	\$1.10
>100	1.0*	\$20749	\$1256	\$22005	22005	\$1.10

- Road density is assumed to be 250 m road spacing for skidder but going up 10% for each 10% increase in slope. When you switch to cable at 40% slope it is assumed again at 250 m road spacing increasing by 10% for each 10% increase in slope. Helilogging road costs are assumed to require only 25% of the road density at 70% slope to prepare staging areas.
- Volume per hectare assumption: 200 m³/ha per TSR2 mean harvest volume per hectare. Assume that for steep slopes that must be partial cut the additional cost is reflected in a special allowance below.
- Road Group 10 is calculated using steepest slope in class, no rock, as (\$8429 + \$176 x Slope %)

2B) Determining Silviculture Costs

Silviculture costs were significantly altered in the Interior Appraisal Manual from 2000 to 2003. Costs are now provided as a Cost/m³ by biogeoclimatic variant. Predictive Ecosystem Mapping area statistics were used to weight the biogeoclimatic variants in the East Kootenay to derive a weighted average silviculture allowance. The range of estimates in the current manual go from \$0.60/m³ for PPdh2 to a high of \$5.78/m³ for ICHmw1. The mean weighted cost estimate is \$4.03/m³. This is assumed to apply to normal stands with 200 m³/ha, and increase or decrease with volume per hectare.

2C Determining Area Based Operating Costs

Area based costs are determined separately from volume based costs as these are impacted by volume/ha. For example it takes the same amount of road to develop a square km of forest whether it has high or low volume and value stands growing on it. Therefore these costs have to be adjusted for volume relative to the estimated mean used to determine cost/m³. Silviculture costs are affected in a similar manner.

Table 6 Determination of Total Area Based Operating Costs

Cost of road / m³ Assumes 200m³/ha	Mean Silviculture Cost/m³	Total Area Based Costs
\$2.29	\$4.03	\$6.32
\$2.91	\$4.03	\$6.94
\$3.59	\$4.03	\$7.62
\$4.35	\$4.03	\$8.38
\$3.69	\$4.03	\$7.72
\$4.45	\$4.03	\$8.48
\$5.28	\$4.03	\$9.31
\$1.10	\$4.03	\$5.13
\$1.10	\$4.03	\$5.13
\$1.10	\$4.03	\$5.13
\$1.10	\$4.03	\$5.13

2D Stocking Affect on Operating Costs

Tree stocking affects operating costs on a site when either volumes decline/ha or the number of pieces increases significantly over the norm. Three indicators of stocking are possible, but only partially inventoried. Where they are present, they can be ranked most desirable to least desirable as follows:

Table 6 Stocking Based Cost Adjustment Factor

Stocking Description	Stocking Class	Tree Density (Where Available)	Crown Closure	Estimated Stocking Factor Impact on Average Operating Costs
Immature Full Stocking	0	< 5000 stems per ha	All	1.00
Age 41-60 or Age 61-80 or Age 80+	0	< 5000 stems per ha	And <25% And 25-34% And 35- 44 %	1.10 Slightly reduced road/ silv. Efficiency
Age 61-80 or Age 80+	0	< 5000 stems per ha	And <25% And 25-34%	1.20 Reduced road/silv efficiency
Age 80+	0	< 5000 stems per ha	And <25%	1.30 Significantly reduced efficiency
Mature Full stocking with Good piece size	1, 3 or R	< 5000 stems per ha	> 45 %	1.00
Mature Slightly Understocked with Good piece size	1, 3 or R	< 5000 stems per ha	35- 44 %	1.10 Slightly reduced road/ silv. effc.
Mature Understocked with Good piece size	1, 3 or R	< 5000 stems per ha	25- 34 %	1.20 Reduced road / silv. effc.
Mature Severely Understocked with Good piece size	1, 3 or R	< 5000 stems per ha	<25 %	1.30 Reduced road / silv. And, yarding efficiency
Mature Severley Understocked	2 or 4	< 5000 stems per ha	All	1.30 Reduced road, silviculture, yarding efficiency
Overstocked Postwood	All	5,000 to 10,000 stems per hectare	All	1.25 Reduced yarding effc.
Repressed	All	>10,000 stems per hectare	All	1.5 Severely reduced road and yarding efficiency

These estimated factors are based on judgement only.

2E) Site Index Cost Adjustment Factor

Site Index affects the amount of volume expected at culmination age, and therefore over which costs are amortized. By relating the expected volume per hectare to the assumed mean of 200 m³/ha these costs can be adjusted accordingly.

Table 7 Site Index Based Cost Adjustment Factor

Site Index Range: (SI curve)	Vol./ha M3	Proportion Factor Compared to Mean of 200 m ³ /ha
<8 (7)	98	0.49
8-9.9 (8)	114	0.57
10-11.9 (10)	144	0.73
12-13.9 (12)	175	0.88
14-15.9 (14)	191	0.96
16-17.9 (16)	200	1.00
18-19.9 (18)	210	1.05
20-21.9 (20)	222	1.11
22-23.9 (22)	233	1.17
24-25.9 (24)	247	1.24
26-27.9 (26)	251	1.26
28-29.9 (28)	251	1.26
30+ (28)	251	1.26

2F) Stand Age Based Cost Adjustment Factor

Stand age above culmination tends to accumulate volume / ha and eventually increase decay and defect. These affect costs per m³ by affecting the merchantable volume recovered per hectare.

Table 8 Reduction in Operating Costs Due to Increased Volume with Age Past Culmination

Site Index Range: (SI curve)	VDYP Culmination Age	Minimum Age For Adjustment to Apply	Calculation of Cost Adjustment Factor Applies to Stands Beyond Culmination Age Only`	Example Factor At Age 200
<8 (7)	161	162+	$((\text{Age}-61) \times 0.0134) - ((\text{Age}-61)^2 \times 0.00003)$	1.28
8-9.9 (8)	152	153+	$((\text{Age}-52) \times 0.0134) - ((\text{Age}-52)^2 \times 0.00003)$	1.33
10-11.9 (10)	138	139+	$((\text{Age}-38) \times 0.0134) - ((\text{Age}-38)^2 \times 0.00003)$	1.38
12-13.9 (12)	130	131+	$((\text{Age}-30) \times 0.0134) - ((\text{Age}-30)^2 \times 0.00003)$	1.41
14-15.9 (14)	115	116+	$((\text{Age}-15) \times 0.0134) - ((\text{Age}-15)^2 \times 0.00003)$	1.45
16-17.9 (16)	99	100+	$((\text{Age}) \times 0.0134) - ((\text{Age})^2 \times 0.00003)$	1.48
18-19.9 (18)	87	88+	$((\text{Age}+13) \times 0.0134) - ((\text{Age}+13)^2 \times 0.00003)$	1.49
20-21.9 (20)	78	79+	$((\text{Age}+22) \times 0.0134) - ((\text{Age}+22)^2 \times 0.00003)$	1.50
22-23.9 (22)	71	72+	$((\text{Age}+29) \times 0.0134) - ((\text{Age}+29)^2 \times 0.00003)$	1.50
24-25.9 (24)	66	67+	$((\text{Age}+34) \times 0.0134) - ((\text{Age}+34)^2 \times 0.00003)$	1.49
26-27.9 (26)	63	64+	$((\text{Age}+37) \times 0.0134) - ((\text{Age}+37)^2 \times 0.00003)$	1.49
28-29.9 (28)	63	64+	$((\text{Age}+37) \times 0.0134) - ((\text{Age}+37)^2 \times 0.00003)$	1.49
30+ (28)	63	64+	$((\text{Age}+37) \times 0.0134) - ((\text{Age}+37)^2 \times 0.00003)$	1.49

Factor derived by taking VDYP run for mean species profile at site index 16 and calculating polynomial curve fit for change in volume above culmination age of 100. It is assumed that change from culmination has the same relative effect on volume over time. Curve fitted to the yield function is: % Increase in Yield = $-0.00003\text{Age}^2 + 0.0134\text{Age} - 1.0038$ ($r^2=0.9794$)

2G) Increase in Operating Costs Due to Increased Decay and Defect With Stand Age Past Culmination

Leading Species	Stand Age	Decay and Defect Impact On Value Recovery Factor
Deciduous	0-40	*0.92
	41+	*0.50
Pl Leading	0-80	*1.00
	81-120	*0.96
	121+	*0.89
Py Leading	0-80	*1.00
	81-120	*0.97
	121+	*0.95
Pa/Pw Leading	0-80	*1.00
	81-120	*0.96
	121+	*0.91
Fir Leading	0-80	*1.00
	81-120	*0.93
	121+	*0.93
Larch leading	0-80	*1.00
	81-120	*0.95
	121+	*0.89
Spruce Leading	0-80	*1.00
	81-120	*0.94
	121+	*0.92
Balsam Leading	0-80	*1.00
	81-120	*0.93
	121+	*0.69
Cedar Leading	0-80	*1.00
	81-120	*0.90
	121+	*0.59
Hemlock leading	0-80	*1.00
	81-120	*0.92
	121+	*0.82

2G) Volume Based Operating Costs

Volume based costs are costs based on each cubic meter of wood processed.

Table 9 Volume Based Operating Costs

Slope %	Yarding Method	Yarding Cost / m3 (Fixed)	Road Maintenance/ m3	Admin. Cost/m3	Total Volume Based Costs
0-10	Ground skid	\$19.63	\$1.90	\$8.88	\$30.41
>10-20	Ground skid	\$20.30	\$1.90	\$8.88	\$31.08
>20-30	Ground skid	\$20.97	\$1.90	\$8.88	\$31.75
>30-40	Ground skid	\$21.64	\$1.90	\$8.88	\$32.42
>40-50	Cable	\$38.64	\$1.90	\$8.88	\$49.42
>50-60	Cable	\$39.96	\$1.90	\$8.88	\$50.74
>60-70	Cable	\$41.28	\$1.90	\$8.88	\$52.06
>70-80	Aerial Heli	\$62.60	\$1.90	\$8.88	\$73.38
>80-90	Aerial Heli	\$62.05	\$1.90	\$8.88	\$72.83
>90-100	Aerial Heli	\$61.50	\$1.90	\$8.88	\$72.28
>100	Aerial Heli	\$60.95	\$1.90	\$8.88	\$71.73

- Ground Skid assumes only slope related factor from appraisal formula as other factors are considered via their own allowances. Average constant is \$19.89. Mean volume of 200m³/ha. Blowdown, small tree, distance to center and defect % are not considered.
- Cable assumes: mean constant of \$32.34, vol/ha of 200 m³, Pl volume of 45%. No blowdown, no partial cut as this is dealt with separately, distance to center of <100km.
- Aerial assumes: Mean constant of \$64.00, mean yarding distance of 0.5km. Simplified formula excludes blowdown, partial cut and distance to center.

2H) Terrain sensitivity Factor

Terrain affects cost of timber removal either because roads cannot be built, or if built they are very costly, or because timber can only be partially cut without impacting slope stability. It is assumed that where terrain issues exist, that special measures for road construction and or bridge construction will be required. Similarly areas with regeneration difficulty could require partial cutting due to the difficulty of reestablishing a new crop in acceptable timeframes. One can rank the various indicators of terrain or regeneration difficulty in the following order of constraint: (Apply terrain indicators hierarchically with the most severe/cost taking priority, and regeneration difficulty is additive)

Table 10 Terrain Based Operating Cost Factor

Terrain Mapping Category	Interpretation	Harvesting Impact	Incremental yarding cost / m3	Est. Road Const. Cost Impact/ m3	Total Cost/m3
Terrain Class V Assumed to be generally on slopes over 70%	Detailed Assessment: Areas with a high likelihood of landslide initiation following timber harvesting or road construction.	Only partial cutting by helicopter allowed, or highly constrained methods of roads and yarding.	\$4.87	\$5.00	\$9.87
Terrain Class U Assumed to be generally on slopes over 70%	Overview Assessment: Unstable Terrain	Only partial cutting by helicopter allowed, or highly constrained methods of roads and yarding.	\$4.87	\$5.00	\$9.87
Terrain Es1	Forest Cover: Extremely fragile or unstable soils	Only partial cutting by helicopter allowed, or highly constrained methods of roads and yarding.	\$4.87	\$5.00	\$9.87
Regeneration Ep1	Forest Cover: Severe regeneration problems caused by geoclimatic factors	Only partial cutting	\$4.87		\$4.87
Terrain Class IV	Areas with a moderate likelihood of landslide initiation following timber harvesting or road construction.	Site specific retention and/or increased road costs.	\$2.00	\$2.00	\$4.00
Terrain Es2	Forest Cover: Significantly fragile or unstable soils.	Constrained methods of roads and yarding with increased costs.	\$2.00	\$2.00	\$4.00
Terrain Class P	Terrain stability overview: Potentially unstable: areas with moderate likelihood of landslide initiation following timber harvesting or road construction.	Constrained methods of roads and yarding with increased costs.	\$2.00	\$2.00	\$4.00
Terrain Class III	Minor stability problems can develop.	Expected to be managed with WTP and road maintenance practices at small incremental cost.	\$2.00	\$1.00	\$3.00
Regeneration Ep2	Forest Cover: Severe regeneration problems caused by biotic factors.	Either partial cut or higher silvicultural costs.	\$4.87		\$4.87
Terrain S, I or II, or Blank	No concerns.	Standard practices.	0		0

Assumes partial cutting cost increment from Sept., 1999 appraisal manual. Assumes extra road costs for detailed assessments, geotextiles, erosion control, end-hauling, maintenance and more likelihood of full deactivation. Costs are estimates.

2I) Distance To Primary Processing Facility

Cycle time to the mill affects stand harvesting economics. Cycle times in the East Kootenay vary from less than 1 to up to 8 hours. A map of isomers of cycle time from primary processing facilities has been developed using appraisal information for the Cranbrook and Invermere TSAs. Each hour of cycle time adds about \$2 to the delivered wood cost.

Table 11 Hauling Cost

Cycle Time	Cost/m3 Highway
0-1 hour	\$2.49
>1-2 hours	\$4.51
>2-3 hours	\$6.53
>3-4 hours	\$8.55
>4-5 hours	\$10.57
>5-6 hours	\$12.59
>6-7 hours	\$14.61
>7-8 hours	\$16.63
>8 hours	\$18.65

Costs assume highway haul, average species composition, constant of \$0.35 adjusted for Fir 21% and Se at 11%.

2J) Manufacturing Cost:

Species affects the relative manufacturing cost estimates in the interior appraisal manual.

Table 12 Species Based Manufacturing Costs

Leading Species	Inventory Type Groups	Manufacturing Cost per m3.
Spruce	21-26	\$37.31
Larch	33-34	\$56.72
White pine	27	\$56.72
Douglas-fir	1-8	\$56.72
Lodgepole pine	28-31	\$38.56
Western red cedar	9-11	\$50.38
Western hemlock	12-17	\$49.40
Ponderosa pine	32	\$56.72
Subalpine fir	18-20	\$41.06
Deciduous*	35-42	\$60.00

2K) Total Operating Cost Calculation:

Total Operating Cost = ((Area Based Costs x Stocking Based Operating Cost Factor) / (Site Index Based Operating Cost Factor x Stand Age Volume Factor x Decay and Defect Factor)) + Volume Based Operating Cost + Terrain Cost Increment + Cycle Time Cost + Species Based Manufacturing Cost.

3) Stand Merchantability (Year 2003 Cost Base)

The combination of the above factors determines the merchantability of a given stand as follows:

Net Stand Merchantability = Average Stand Product Value – Total Operating Costs

Table 12 Merchantability Classes:

Merchantability Class	Merchantability Range	Map Colour
High Return Stands – Stands expected to be merchantable in any market conditions and return high stumpage to the land owner.	>= \$45.00	Medium Green
Moderate Return Stands – Stands expected to be profitable in most market conditions and return fair stumpage to the landowner.	\$30.00-<\$45.00	Pale Green
Economic Stands – Stands expected to be viable in most market conditions (>90% of the time) and return modest stumpage to the landowner.	\$15.00 - < \$30.00	Very light Green
Marginal Stands – Stands expected to be viable in moderate to good markets, but return little stumpage to the landowner.	\$0 - <\$15.00	Light Yellow
Deficit Stands – Stands expected to generate a small operating deficit in most markets (> 90 % of the time)	-\$15.00 - <\$0.00	Light Orange
Moderate Deficit Stands – Stands expected to generate an operating deficit in all markets (> 90 % of the time)	-\$30.00 - <\$15.00	Light Reddish Orange
High Deficit Stands – Stands expected to generate a significant operating deficit in all markets.	-\$45.00 - < -\$30.00	Pink
Severe Deficit Stands – Stands expected to generate severe deficits in all markets.	<-\$45.00	Violet

Cautions:

This analysis approach is not able to, nor intended to, account for sensitivity of harvest merchantability due to rule sets imposed on a stand such as riparian, ungulate winter range, etc. These factors can be addressed through subsequent modelling or analysis. There are times where roads are not feasible due to unstable terrain, adjacent canyons or other obstacles. Generally this occurs where a number of other merchantability features are already placing the stand in a less desirable stratum.

Old stands or overstocked stands that may not be economic due to decadence may occupy highly productive growing sites. In the East Kootenay only a small fraction of the land base has old stands and these are likely to be recruited for Old Growth Management Areas. Overstocked stands may also be rehabilitated with an expected gain in productivity and piece size.

The model may be adjusted to account for old growth site index or stand disturbance by adjusting site index per the OGSI system, and for disturbance by normalizing crown closure of near mature stands.

Outcomes:

The attached graph illustrates the extent of each Version 1.0 merchantability class described above. Note that this area is gross including parks, some private land, Indian Reserve etc. Several thousand hectares of potentially operable area outside current operability lines was identified. Also many thousands of hectares of uneconomic forest within the operability line is identified which can be considered for biodiversity retention. Judging from the map results, the net result could add an estimated 5-10% to the AAC potential of the Cranbrook TSA. Actual effects may be tested in TSR3 using this coverage as a tool to identify the operable land base and biodiversity retention areas. Also it will be possible to test how far one would have to harvest into deficit stands to maintain or increase the AAC to a given target level.

