TIMBERLINE FOREST INVENTORY CONSULTANT LTD.

DATA ANALYSIS

Mackenzie TSA Operability Assessment in Ungulate Winter Range Units

MARCH 2004

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MACKENZIE TSA OPERABILITY ASSESSMENT IN UNGULATE WINTER RANGE UNITS

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1.0 INTRODUCTION

As part of Slocan's commitment to sustainable forest management, late in the third quarter of the 2003/2004 Forest Investment Account (FIA) fiscal year, Slocan – Mackenzie Operations issued a request for proposal to conduct an operability assessment within selected ungulate winter range (UWR). The objective of the project was to provide an operability assessment to meet proposed UWR objectives drafted in March 2003 by the Environmental Stewardship Division of the Ministry of Water, Land, and Air Protection (MWLAP). The project is to provide input into the development of an UWR management strategy.

For strategic timber supply analyses, such as timber supply review (TSR), the productive forest land is classified as either operable or inoperable. Operable areas are those from which trees could reasonably be expected to be harvested. A survey is typically conducted, which results in the definition of an operability line, defining the extent of the operable land base. This line gives a static depiction of operability, reflecting any physical, and possibly, current economic limitations that would prevent access to timber.

1.1 Proposed Ungulate Winter Range Management Strategy

The project addressed three of 14 UWR areas in the Mackenzie Timber Supply Area (TSA). A key map, Figure 1, displays the spatial distribution of the three UWR areas addressed in the project. A project completed by the MWLAP, UWR areas were determined by applying a three km buffer around Terrestrial Lichen Habitat Units (TLHU) that contain abundant terrestrial lichen habitat. Management strategies were developed to address:

- the sustainability of food supply, lichen habitat;
- displacement as a result of industrial activity; and
- predation on caribou.

Key aspects of the management strategies are aimed at:

- minimizing fragmentation within UWR areas;
- minimizing industrial activity within UWR areas while they are occupied by caribou;
- minimizing access development to limit predation; and
- sustaining terrestrial lichen habitat by maintaining 50% of the Terrestrial Lichen Habitat Unit (TLHU) to be less than 70 years old and 50% between 70 and 140 years of age.

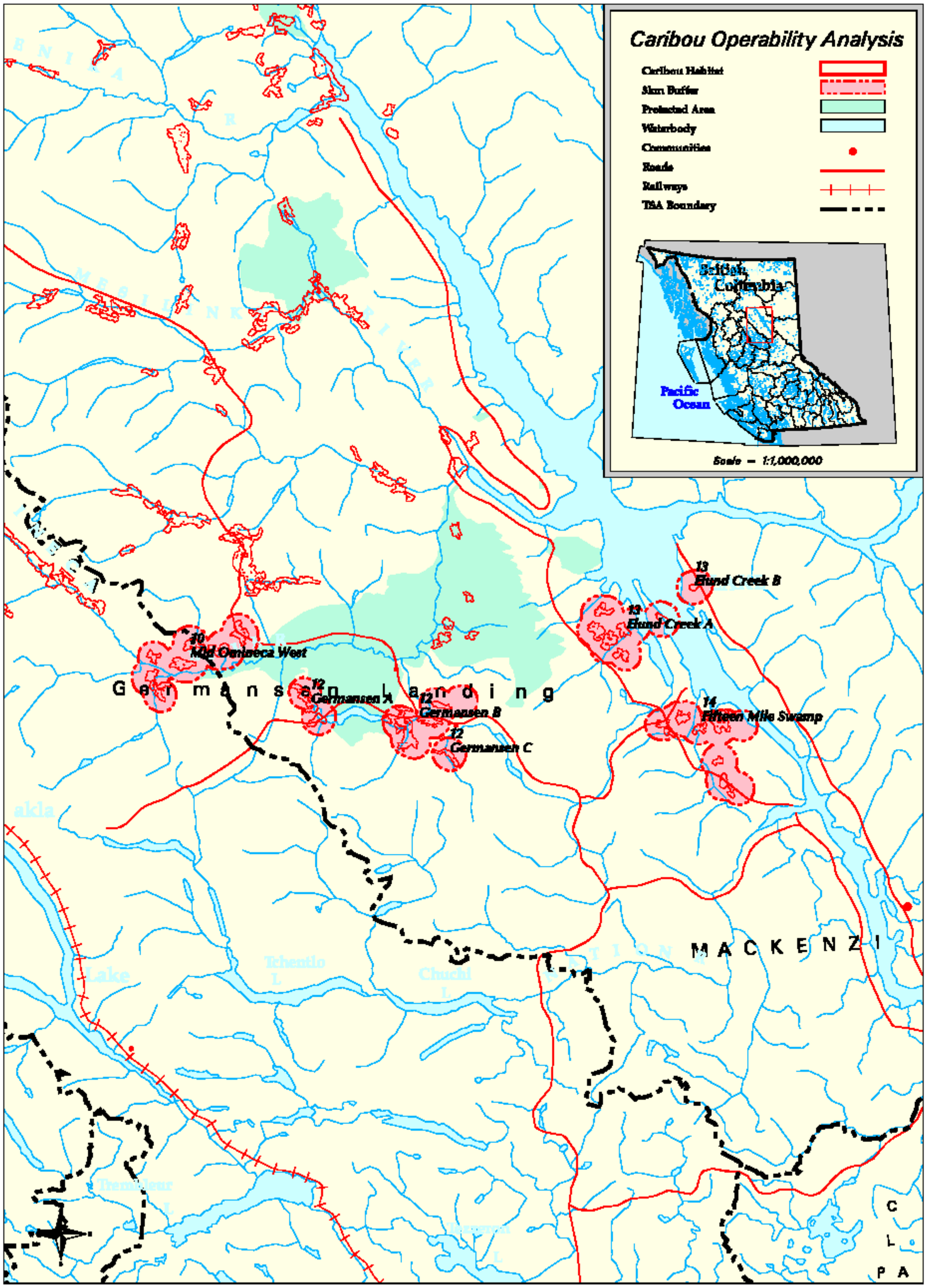

Figure 1 Physically Accessible Land Base Based on Total Chance Road Network

1.2 FIA Standards

The operability standards document (referred to above) on the FIA website lists several guidelines for projects of this type:

- that projects be undertaken in two phases:
  - a problem analysis that examines access issues and analysis/modelling needs; and
  - the development of algorithms and procedures to improve the utility of operability information for timber supply reviews.
- that operability be based on terrain and forest characteristics that impact logging costs;
- that operability not be based on any factors that are unrelated to the economics of logging;
- that the dynamic nature of log value be recognized and addressed;
- that any new spatial datasets developed for the project be among the project deliverables; and
- that all procedures and data sets be documented.

All work undertaken on this project complied with these guidelines.

2.0 PROBLEM ANALYSIS

2.1 Uses of Operability Mapping

Operability mapping is used in strategic planning, primarily for the timber supply analysis process. The Chief Forester makes the final allowable annual cut (AAC) determination based on the material provided by the licencee and feedback provided from agency staff and the public.

The determination of the timber harvesting land base (THLB) is accomplished through a netdown procedure. Non-forest land (lakes, alpine, etc) and land not managed for forestry (i.e. parks, special leases and licences) are removed early in the process. In the Mackenzie TSA, the operability information is used in conjunction with stand attribute parameters in merchantability reductions. The merchantability reductions are netted-out shortly after non-forest non-productive reductions, the associated area reduction is substantial.

The base case of a TSR is intended to model “what is” rather than “what if”. Consequently, the area contained within operability boundaries should be reasonably available for harvesting within the term of the plan (apart from access development costs) given the logging standards and practices of the day. They should be neither unduly conservative (excluding areas adjacent to recently logged blocks on the same road heading) or wildly optimistic (excluding only Class IV terrain). Unfortunately, markets and logging technology evolve continuously, whereas operability maps are reviewed and revised infrequently.

2.2 Physical Accessibility

The part of the productive land base that could be accessed using current harvesting systems is said to be physically operable. No consideration is given to the economics of harvesting a given stand; if the timber can be yarded to a road, either using conventional yarding methods or by helicopter, the stand is physically operable. In applying this definition to a specific forested area, the practical questions are as follows:

- How far can the existing network of roads be extended?

- How far from this proposed road network can timber be yarded?

Previous attempts at operability mapping answered both of these questions implicitly, i.e. road networks were not explicitly mapped to determine if the timber was accessible. For strategic planning purposes, it is useful to know the extent of the physically accessible land base. Such an inventory also provides a foundation for assessing economic operability to assess existing or new management directions and their implications on forest operation feasibility.

2.3 Economic Operability

The economically operable land base is the portion of the physically accessible land base that can be profitably harvested under a given set of assumptions about logging costs and timber prices.

Conceivably, the profit margin from the harvesting of a given stand can be calculated as timber value minus logging cost plus stumpage. Any stand with a positive margin is considered economically operable. The challenge is in reasonably estimating the expected timber value and logging cost for each stand.

The procedure used for to estimating timber value started with the forest inventory, since this is the only data set that covers the entire productive forest land base. From the forest inventory, current volume per hectare by species was retrieved. Based on this information, stand selling prices were estimated. To achieve this, two steps were necessary:

1. For stands currently below their expected rotation age, the volume per hectare at the approximate time that they will be harvested was estimated.
2. The average selling price per cubic meter was estimated – combining inventory data with representative cutting permit information were used.

A procedure for estimating the cost of logging each stand was developed. At an operational level, licencees do this as part of the budgeting and cash flow forecasting processes, and when preparing a cutting permit application. Logging cost information is normally broken out into phases, such as:

- development;
- falling;
- yarding;
- loading;
- hauling;
- camp;
- forestry; and
- overhead and administration.

The Interior Appraisal Manual specifies the following phase breakdown for cutting permit applications:

- development;
- tree-to-truck;
- transportation; and
- administration, and forestry.

One of the problems in assigning a logging cost to all productive (or perhaps just physically accessible) stands was to devise a system that captures the major logging cost differences between stands without relying on large amounts of information, or required details lost in aggregations, that is difficult (or impossible) to obtain and prohibitively expensive to compile. A way of using both of these sources of data to develop strategic-level economic information were devised.

3.0 METHODOLOGY

The operability model was developed in two steps:

1. The portion of the productive land base that is physically accessible was determined.
2. An economic model was built to evaluate the profitability of individual stands based on timber value and expected logging costs.

This economic model was then used to generate a base case set of operability maps.

3.1 Physical Accessibility

The physically accessible portion of the land base is that which can be harvested, assuming current road building and yarding technologies. Conceptually, physical accessibility is unrelated to environmental or economic constraints to logging. Practically, economic consideration can't be ignored entirely. With enough money, roads can be built through very difficult terrain. For very high value timber, long helicopter yarding turns are feasible.

The extent of the physically accessible land base was determined by completing a total chance road network for the selected UWR units (an example is shown in Figure 2). Maps at a scale of 1:50,000 were used as a working base. Existing and forest development plan proposed roads were displayed, along with the extent of the productive forest land base. Terrain was shown by plotting contour lines from TRIM II to assist in developing a total chance road plan. On this base, the network of forest roads was extended as far as is reasonably possible. Efforts were made to access all old growth stands with inventory volumes greater than 140 m3 per hectare. Physical accessibility was determined using a total chance road network. Any stands within 1250 meters of an existing or proposed road were considered accessible.

Appendix I provide a more detailed description of the procedures for creating the total chance road network.

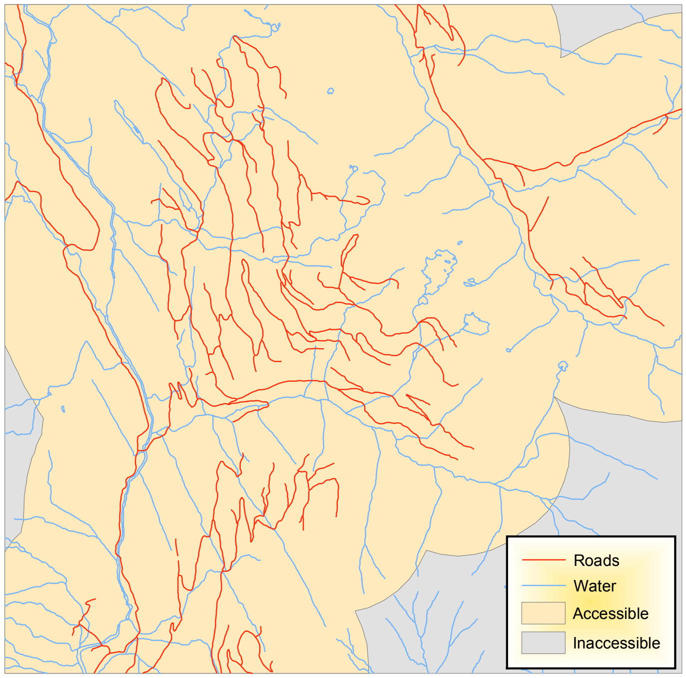

Figure 2 Physically Accessible Land Base Based on Total Chance Road Network

3.2 Economic Operability

The economically operable land base is comprised of stands that can be profitably logged. In order to apply this definition, it will be necessary to:

- determined the value for each stand timber;
- determined the delivered wood cost for each stand; and
- set criteria for profitability and produce a base case operability map.

The Interior Appraisal Manual – specifically the Comparative Value Pricing System, documents a framework for compiling logging costs and timber values. The issue of evaluating profitability and generating economic operability maps are addressed in *Section 3.3 Base Case Operability Map*.

3.2.1 Timber Value

Timber value for each stand was determined based on the forest inventory, a summary compilation of all 2002 Slocan Mackenzie cutting permits, and log price information from the Ministry of Forests (MoF) Revenue Branch.

The forest inventory provided volume per hectare, by species, for each stand. Existing mature stands were projected to 2003 using VDYP (Variable Density Yield Prediction). Any stands less than 100 years old were projected to an age of 100 years for the purpose of determining their value. Stands less than 25 years old were projected using TIPSY (….   ), under the assumption that they are managed stands. Table 1 summarizes the projection methods.

Table 1 Volume Projection Methods for Operability Mapping

Stand Age Range	Volume Projection Method
0 to 25 years	Project to 100 years using TIPSY
26-100 years	Project to 100 years using VDYP
100+ years	Project to 2003 using VDYP

To estimate the grade distribution for each species, cutting permit averages were used. The percentage grade distribution was applied to each species in every stand (projected and existing), to derive stand value.

Log prices by species and grade, available from the MoF Revenue Branch website at http://www.for.gov.bc.ca/hva/timberp/CVP_Parameters/cvp_interior2004.htm, were applied to the assigned grade distribution to arrive at a stand value. Grade distributions for each species from cutting permit averages were applied to each species in every inventory stand (projected and existing), to derive stand value.

Following a first review of initial base operability maps, inventory volumes were identified as a significant deficiency that resulted in the reclassification of the majority of areas as inoperable. Volumes were subsequently adjusted to reflect cruise volumes per hectare for individual UWR units. Table 2 displays a comparison of mature inventory volumes to cruise compilation volumes and their associated adjustment factors for each UWR unit.

Table 2 Inventory Volume Adjustments to Reflect Cruise Information

UWR Unit	Mature Inventory Volume (m3/ha)	Representative Cruise Volume (m3/ha)	Inventory Adjustment Factor
Elund Creek A, B	247	275	1.11
Fifteen Mile Swamp	275	308	1.12
Germansen A, B, C	241	315	1.30
Mid Omineca West	263	395	1.50

3.2.2 Delivered Wood Cost

The procedures for estimating delivered wood cost are based on Section 4 of the Interior Appraisal Manual. Phase cost categories recognized are:

1. Development.
2. Tree-to-truck.
3. Log transportation.
4. Other.

The delivered wood cost for a stand was the sum of the phase costs.

3.2.2.1 Development Costs

Development costs cover the construction of new roads and bridges in undeveloped areas and the reconstruction of existing roads in previously developed areas. These costs were compiled, for individual UWR unit, using the inventory information within the appraisal framework, then calibrated with representative cutting permits provided by the licencees.

For new road and bridge construction, the Interior Appraisal Manual provided two approaches to cost estimation:

1. Tabular Cost Estimates.
2. Detailed Engineering Cost Estimates.

Tabular costs were used for all proposed roads in this study. The procedure to this point has established the total cost for building all required new roads in the UWR unit. By using a Geographic Information System (GIS) to overlay the area that these new roads develop on the forest cover, the timber volume associated with these roads were calculated. By dividing total construction cost ($/kilometer) by the total timber volume developed, an average development cost per cubic meter was calculated for the undeveloped timber in a UWR unit. This was the first, and the most difficult to calculate, of the four phase costs required to compute total logging cost.

3.2.2.2 Tree-to-Truck Costs

Once the total chance road network was established, tree-to-truck costs were calculated.

The tree-to-truck cost calculations are specific to Biogeoclimatic (BGC) zones in the Interior Appraisal Manual as follows:

$$\begin{gathered}\$/m3 = \text{BGC (Zone constant} + (6.68 \times \text{slope\%}/100) - (4.67 \times \text{vol/ha}/1000) \\ = 3.45 \times \text{BD \%}/100) + (6.96 \times \text{Defect \%}/100) + (6.57 \times \text{small treed}) \\ + (1.71 \times \text{New dist x }/100)\end{gathered}$$

Table 3 contains details on formula variables.

Table 3 Tree to Truck Cost Variables

Variable	Source
BGC Constant	Interior Appraisal Manual
Vol/hectare	Projected Inventory
BD (Percent Blow down)	Representative Cutting Permits
Defect %	Representative Cutting Permits
Smalltreed	Representative Cutting Permits
NewDist	Projected Inventory and Road Network Information

3.2.2.3 Transportation Costs

For individual UWR units, transportation costs were calculated using the Interior Appraisal Manual formula, displayed below.

$$\$/m^3 = 0.56 + (1.39 \text{ x } CT) - (2.48\% \text{ x } CE\%/100) + (1.42 \text{ x } HE\%/100) - (0.81 \text{ x } SP\%/100)$$

Table 4 contains details on formula variables.

Table 4 Transportation Cost Variables

Variable	Source
CT-cycle time	Projected Inventory Road Network
	Haul Speed Agreement
Species % Composition	Projected Inventory

3.2.2.4 Administration and Other Costs

Administration and other forestry costs specified include:

- road management;
- administration and other; and,
- basic silviculture.

The current allowances applied to each polygon were:

- \$1.80/m^3 road management costs;
- \$6.58 / m3 for general and administrative costs;
- \$5.40 / m3 for engineering and forestry costs; and
- \$1234/ha to \$1555/ha for basic silviculture costs depending on BGC zone/sub-zone.

3.3 Base Case Operability Map

After the delivered wood cost and timber value were compiled and spatially linked, the potential profit margin for each stand was calculated as:

$$\text{Profit} = \text{Timber Value} - \text{Delivered Wood Cost}$$

Any stand with a positive profit margin, or a profit margin above some other specified minimum value, is economically operable.

Once the model was applied through a GIS, it was straightforward to produce an economic operability map. In fact, many different maps could be produced. As the economic inputs such as timber value, phase costs, and required profit margin, vary, the map of economically operable timber will change.

While logging costs are precisely defined, more latitude exists for specifying log prices and setting a profit margin requirement.

As described earlier, timber value is driven by log price tables produced by the MoF Revenue Branch. These tables show periodic average log prices by species and grade. They are recompiled and republished every three months. Each of these tables is a snapshot of a point in the business cycle. If log prices from late 1995 are used in the timber value calculation, the resulting map will show more economically operable timber than if a price table from 2001 is used. This will provide an interesting look at the relationship between log prices and economically available timber, to potentially lead to sensitivity analyses in timber supply or assessing the viability of management constraints. The approach used a potential profit margin of ≥ 0 as a cut off for operability.

4.0 RESULTS

Results of the operability project for selected UWR units in the Mackenzie TSA are a series of maps displaying the base operability within the UWR units and an assessment of implications to operability when considering the proposed management strategies for UWR units.

4.1 Base Operability Maps

Operability maps were produced at a scale of 1:50,000 for each of the UWR units. The maps displayed the UWR unit (yellow), TLHU (red), existing and proposed roads (black and purple) and shaded inoperable areas. Figure 3 presents a sample of the map.

Complete maps are provided in .pdf and .hp plot file format in the project CD, provided in Appendix II.

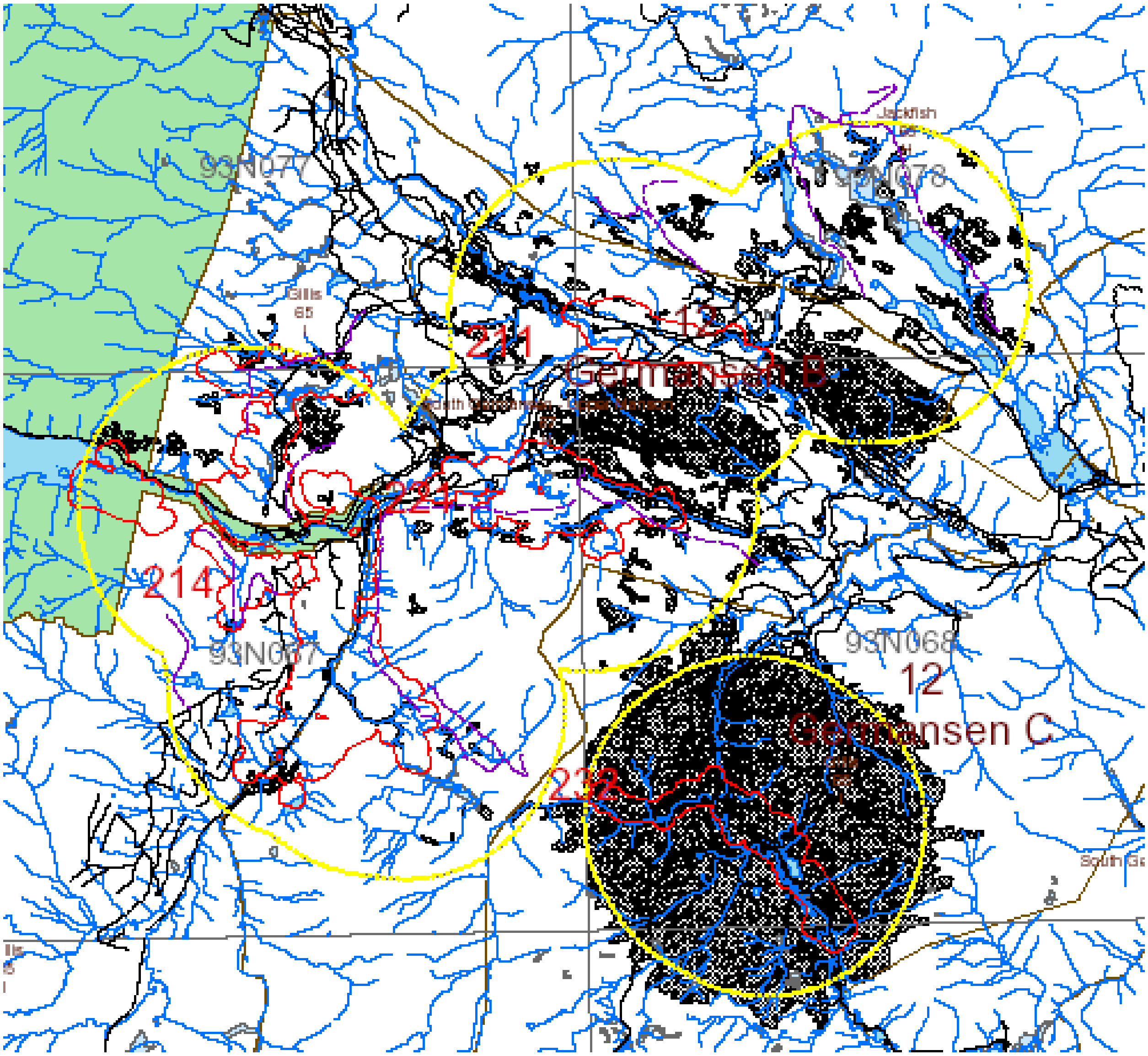

Figure 3 Sample Operability Map in a UWR Unit

Overall, the operability project resulted in small refinements to the existing operability mapping, which subsequently lead to portions of the existing THLB to be excluded as a result of economic factors. Table 5 summarizes the average economic factors and Table 6 displays resulting changes in the THLB from TSR 2 to post UWR operability for each of the UWR units.

Table 5 Summary of Economic Information from Operability Mapping

UWR Unit	Average Value	Average Manufacturing Costs	Average Overhead Costs	Average Transportation Costs	Average Development Costs	Average Tree to Truck Costs	Average Silviculture Costs	Average Profitability
Elund Creek A	$88.25	$34.68	$6.58	$9.73	$3.51	$18.00	$3.35	$15.89
Elund Creek B	$88.63	$34.68	$6.58	$8.23	$3.51	$15.00	$3.25	$20.88
Fifteen Mile Swamp	$86.33	$34.68	$6.58	$6.11	$2.29	$17.00	$3.51	$19.66
Germansen A	$103.06	$34.68	$6.58	$13.07	$3.24	$21.57	$3.64	$23.78
Germansen B	$102.58	$34.68	$6.58	$11.54	$2.47	$20.78	$2.99	$27.04
Germansen C	$102.92	$34.68	$6.58	-$99.00	-$99.00	-$99.00	-$99.00	-$99.00
Mid Omineca West	$115.83	$34.68	$6.58	$16.68	$2.32	$22.41	$8.26	$28.40

Table 6 Timber Harvesting Land Base Changes as a Result of Operability Mapping

UWR Unit	Gross Area (ha)	TSR 2 THLB (ha)	Revised THLB (ha)
Elund Creek A	19,239	13,254	8,516
Elund Creek B	3,433	2,971	2,108
Fifteen Mile Swamp	25,373	15,694	11,221
Germansen A	9,995	3,537	3,065
Germansen B	20,611	13,848	12,550
Germansen C	4,171	2,982	0
Mid Omineca West	11,115	5,233	4,902

4.2 Implications of Ungulate Winter Range Management Strategies

The project addressed three of 14 UWR units in the Mackenzie TSA. Key aspects of the management strategies are aimed at:

- minimizing fragmentation within the UWR units;
- minimizing industrial activity within the UWR units while they are occupied by caribou;
- minimizing access development to limit predation; and
- sustaining terrestrial lichen habitat by maintaining 50% of the TLHU to be less than 70 years old and 50% between 70 and 140 years of age.

All of the UWR management strategies could conceivably result in increased operating costs to a varying degree, by virtue of increasing the complexity of management considerations within the UWR units. However, the following elements of the proposed UWR management strategies impact the economic operability of stands:

1. Maintaining 50% of the TLHU to be less than 70 years old and 50% between 70 and 140 years of age.
2. No industrial activity within UWR units while they are occupied by caribou.

The first element as described in the proposed management strategies requires that 45% to 55% of the TLHU area within each UWR unit be of 70 to 140 years of age. Table 7 summarizes the current distribution for lichen stage in TLHU by UWR unit. The first lichen stage, the recruitment stage, consists of stands from 0 to 70 years of age. The second category, thrifty lichen stage, consists of stands from 71 to 140 years of age. The third category, decadent, is not explicitly addressed in the proposed management strategy and consists of stands greater than 140 years of age. The guideline would restrict harvesting to only 50% of the TLHU area over a period of 70 years. Significant portions of TLHU within UWR units are currently older than 140 years of age. The size of individual TLHU is sufficient to not isolate significant amounts of volume.

Table 7 TLHU Stage Distribution within each UWR Unit of the Project Area

UWR Unit	Lichen Stage	Area (ha)	Distribution (%)
Elund Creek A	Decadent	583	9%
Elund Creek A	Recruitment	1,644	27%
Elund Creek A	Thrifty	3,960	64%
Elund Creek B	Recruitment	168	24%
Elund Creek B	Thrifty	534	76%
Fifteen Mile Swamp	Decadent	1,073	12%
Fifteen Mile Swamp	Recruitment	5,781	65%
Fifteen Mile Swamp	Thrifty	2,052	23%
Germansen A	Decadent	761	16%
Germansen A	Recruitment	1,576	33%
Germansen A	Thrifty	2,382	50%
Germansen B	Decadent	1,178	19%
Germansen B	Recruitment	674	11%
Germansen B	Thrifty	4,302	70%
Germansen C	Decadent	98	10%
Germansen C	Recruitment	44	4%
Germansen C	Thrifty	842	86%
Mid Omineca West	Decadent	693	19%
Mid Omineca West	Recruitment	620	17%
Mid Omineca West	Thrifty	2,258	63%

A closer examination of lichen stages within each TLHU revealed that all three lichen stages were present within each TLHU. Table 8 displays TLHU specific lichen stage for the Fifteen Mile Swamp UWR unit and Germansen A UWR unit. The two UWR units were selected to depict different issues that may require further consideration and clarification within the proposed UWR strategy.

Table 8 TLHU Stage Distribution within the Fifteen Mile Swamp and Germansen A UWR Units

UWR Unit	TLHU	Lichen Stage	Area (ha)	Distribution (%)
Fifteen Mile Swamp	212	Decadent	93	1%
Fifteen Mile Swamp	212	Recruitment	362	4%
Fifteen Mile Swamp	212	Thrifty	132	1%
Fifteen Mile Swamp	213	Decadent	191	2%
Fifteen Mile Swamp	213	Recruitment	494	6%
Fifteen Mile Swamp	213	Thrifty	476	5%
Fifteen Mile Swamp	215	Decadent	118	1%
Fifteen Mile Swamp	215	Recruitment	1,848	21%
Fifteen Mile Swamp	215	Thrifty	317	4%
Fifteen Mile Swamp	219	Decadent	269	3%
Fifteen Mile Swamp	219	Recruitment	361	4%
Fifteen Mile Swamp	219	Thrifty	176	2%
Fifteen Mile Swamp	227	Decadent	49	1%
Fifteen Mile Swamp	227	Recruitment	193	2%
Fifteen Mile Swamp	227	Thrifty	391	4%
Fifteen Mile Swamp	233	Decadent	82	1%
Fifteen Mile Swamp	233	Recruitment	2,312	26%
Fifteen Mile Swamp	233	Thrifty	77	1%
Fifteen Mile Swamp	234	Decadent	100	1%
Fifteen Mile Swamp	234	Recruitment	150	2%
Fifteen Mile Swamp	234	Thrifty	253	3%
Fifteen Mile Swamp	235	Decadent	171	2%
Fifteen Mile Swamp	235	Recruitment	60	1%
Fifteen Mile Swamp	235	Thrifty	230	3%
Germansen A	203	Decadent	592	13%
Germansen A	203	Recruitment	259	5%
Germansen A	203	Thrifty	1,497	32%
Germansen A	220	Decadent	170	4%
Germansen A	220	Recruitment	1,317	28%
Germansen A	220	Thrifty	884	19%

The distribution of lichen stages within the Fifteen Mile Swamp UWR unit for individual TLHU is surprisingly fragmented. If the intent of the UWR management strategy is to minimize fragmentation, it may be best to manage entire TLHU as one lichen stage. The Germansen A UWR unit could conceivably allow for an additional 20 hectares of harvest. Priority of harvest within is not specified within the proposed UWR management strategy. In the case of the Germansen A UWR unit, priority should be to harvest areas of TLHU which are at decadent lichen stage.

The second element of the proposed UWR management strategy which has significant implications on forest operations, disallows industrial activity within UWR units when caribou occupy the TLHUs. The implications are twofold. First, all of the UWR units examined are transected by a main access corridor. The proposed strategy would prohibit the industrial use of main access roads within winter months, causing significant logistic problems to forest operations. Secondly, a significant portion of the UWR units are classified as winter harvest only, whereby the site conditions are not conducive to summer harvest as they result in excessive site degradation. Table 9 provides a description of breakup ground as provided by Slocan. Areas not identified as breakup ground require harvesting operations to occur during winter conditions. Unfortunately, current ecological information with site series mapping was not completed at the time of the analysis for consideration.

Table 9 Definition of Winter Harvest Only

BEC zone/subzone variant	Site Series
SBS mk1	02/03/04
SBS mk2	02/03
SBS wk2	02/03
BWBSdk1	02/03
ESSFmv3	02

5.0 CONCLUSIONS

The new operability model that combines economic viability with physical accessibility has resulted in refinements to the existing TSR II operability. Inventory volume estimates are significantly underestimated within UWR units.

The size and lichen stage distribution of individual TLHU will likely lead to negligible implications on operability. The access restriction within UWR units when caribou are utilizing the TLHU has significant implications on forest operations as the majority of UWR units are transected by a major access road.

6.0 RECOMMENDATIONS

1. Complete Phase 1 and Phase 2 VRI to better reflect operational volumes strategically.
2. Complete the ongoing PEM to provide site series level information.
3. Reconsider access restrictions in UWR units when occupied by caribou.
4. Conduct a review of all UWR units and TLHU that would explicitly detail lichen stage distribution, identify considerations and outline a management TLHU plan for each UWR accounting for forest operations and the proposed UWR management strategies.

APPENDICES

APPENDIX 1

Total Chance Road Network Guidelines

Maps were plotted at a 1:20,000 scale, and areas where the ungulate winter range (UWR) units with Terrestrial Lichen Habitat Units (TLHU) were assessed and potential conifer timber sources were located and identified, a total chance paper plan for the identified areas was prepared using the following criteria:

- logical block boundaries were identified using forest cover labels for species, age class, and height class;
- age classes 6,7, and 8 were lumped together as well as age classes 3,4, and 5. This would assist in determining which blocks would be harvested in the immediate future and 70 years from now as indicated in the caribou management recommendations;
- future road networks were developed using existing road networks and attempted to minimize road lengths and stream crossings were possible;
- any potential timber sources that were located along road networks leading to UWR were identified for "opportunity" blocks to minimize dead road costs;
- maximum (favorable and adverse) road grades followed road location standard operating procedures provided by client;
- distances between in block roads were determined using the harvesting system standard operating procedures provided by the client; and
- local knowledge from the Timberline forestry engineer was utilized to assist in the block and road network development.

APPENDIX II

Base Operability Maps

(compact disk)