Final

Regional Access Management Planning (RAMP)

PROJECT REPORT

Prepared For: fRI Research (Foothills Landscape Management Forum) & Government of Alberta

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1. Introduction

Access is a primary concern in most caribou ranges across Alberta where there is overlap in high-value resources and critical caribou habitat. Thus, access management is a key component to caribou range planning in a working landscape as highlighted in the mediator report Setting Alberta on the Path to Caribou Recovery (Denhoff, 2016). The report states the necessity of “a well-coordinated multi-company road access plan for energy, forestry, and other users.”

Specific to the Little Smoky / A La Peche caribou range, the Government of Alberta has outlined specific requirements for access management within the region. The draft range plan (June 2016) outlines the objectives to minimize new linear disturbances and identify opportunities to restore existing linear disturbances that will be implemented through the approval of a coordinated regional access development plan.

This project has been initiated to support the development of a regional access management plan (RAMP) through modeling potential access corridors under an integrated landscape approach and comparing the results to the current as-built network and previous regional access plans (RAD plan). Key indicators will be developed for assessing outcomes from access corridors for different audiences. The outcomes of this analysis will be used to develop a final regional access management plan supporting the caribou range plan requirements.

The intent of this project is to develop a transparent, repeatable, data-driven approach to reduce the overall impact to caribou from road corridor development. A phased approach was developed for this project beginning with a proof-concept-analysis and then scaling up to range level corridor analysis for the Little Smoky / A La Peche caribou range.

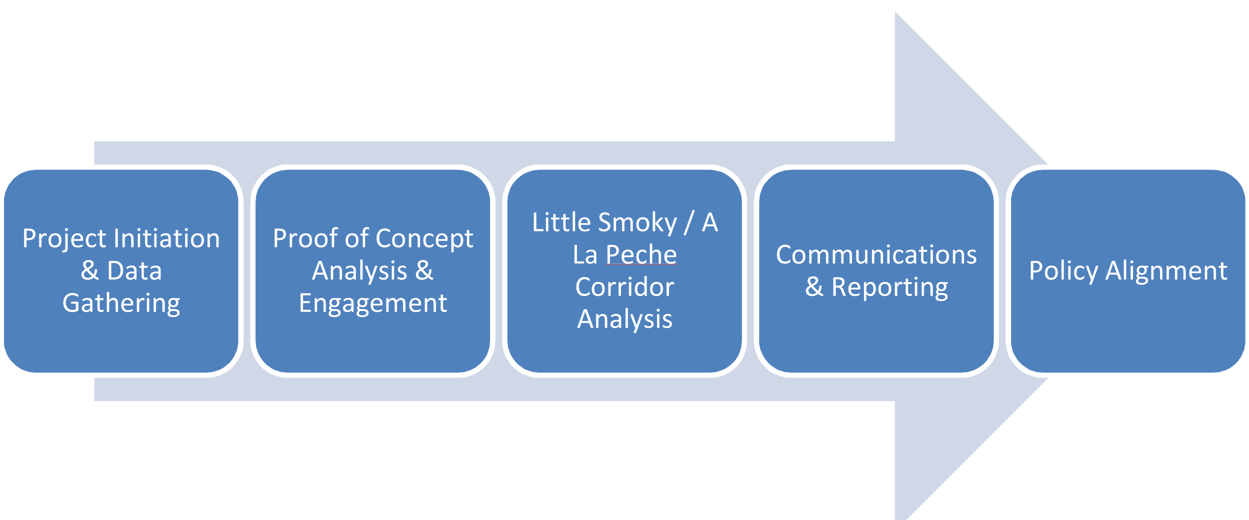


Figure 1-1 Project approach

This report discusses the process that was developed, the model framework, outcomes for the proof-of-concept analysis and the corridor analysis completed for the Little Smoky / A La Peche caribou range.

The project was co-sponsored by fRI Research and Government of Alberta with regular participation from an advisory group consisting of energy and forestry industry representatives from the Foothills Landscape Management Forum (FLMF) Industry Sub Group (Figure 1-2).

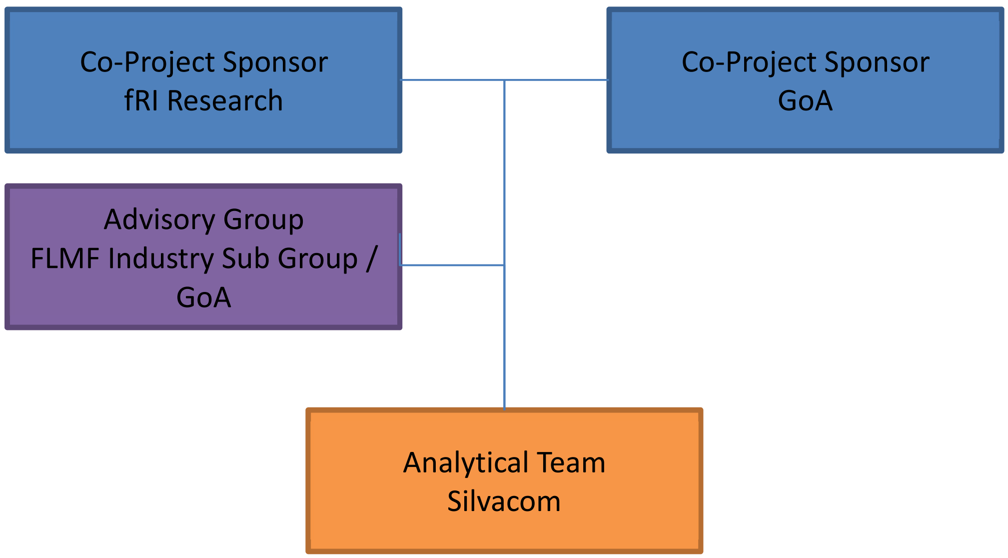


Figure 1-2 RAMP project team

2. RAMP Planning Process

The first objective was to build a process with government and industry representatives for regional access management planning. A six-step iterative and interactive process (Figure 2-1) was developed through the initial proof-of-concept analysis beginning with multi scenario modeling and analysis through to corridor delineation, implementation and monitoring. It is important to highlight that the process is intended to create primary access corridors only to target resource areas and not actual well or forest harvest locations.

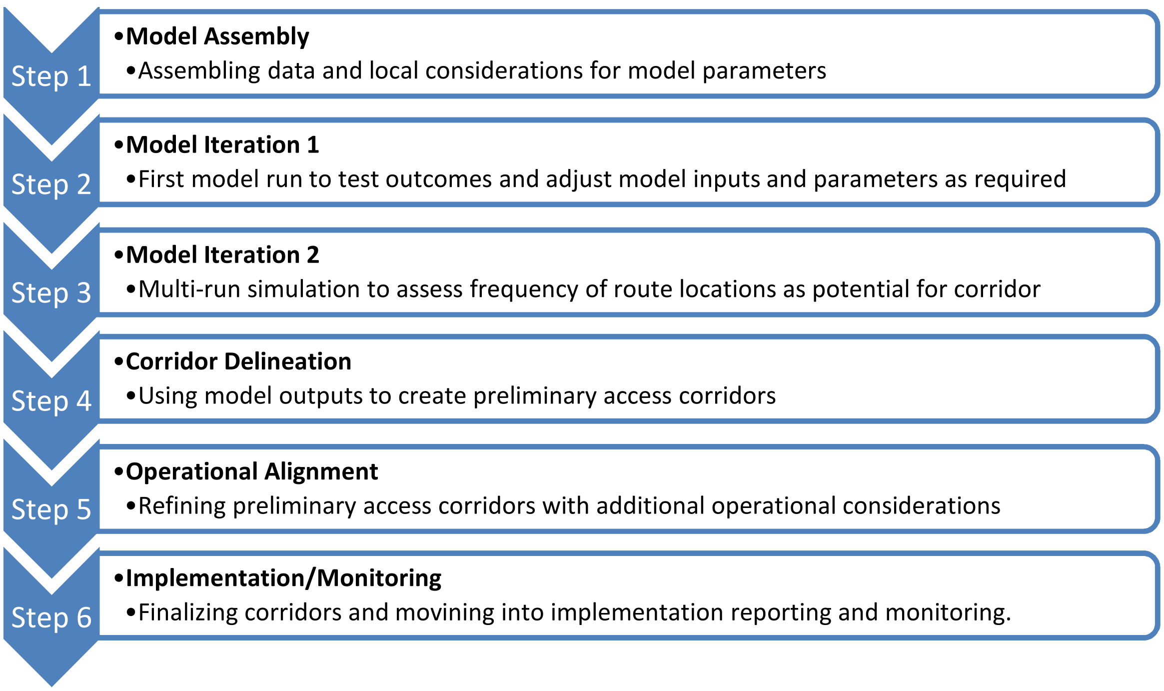


Figure 2-1 Regional access management planning process

This process leverages analytical expertise combined with local knowledge from government and industry to establish model parameters, model initial corridor potential and refine final corridor selection. A more detailed version of this process is provided in (Appendix A Draft Regional Access Management Planning Process). This process focuses on the technical approach and there are several key checks at each stage. Rules of governance will need to be established for the framework moving forward.

3. Modeling Methodology

A modeling framework has been developed leveraging a least cost pathways approach to identify potential road corridors to access forestry and oil & gas resources within a township. These modeled corridors are then used to analyze impacts to key indicators which evaluate the benefits and trade-offs of a proposed corridor network (Figure 3-1).

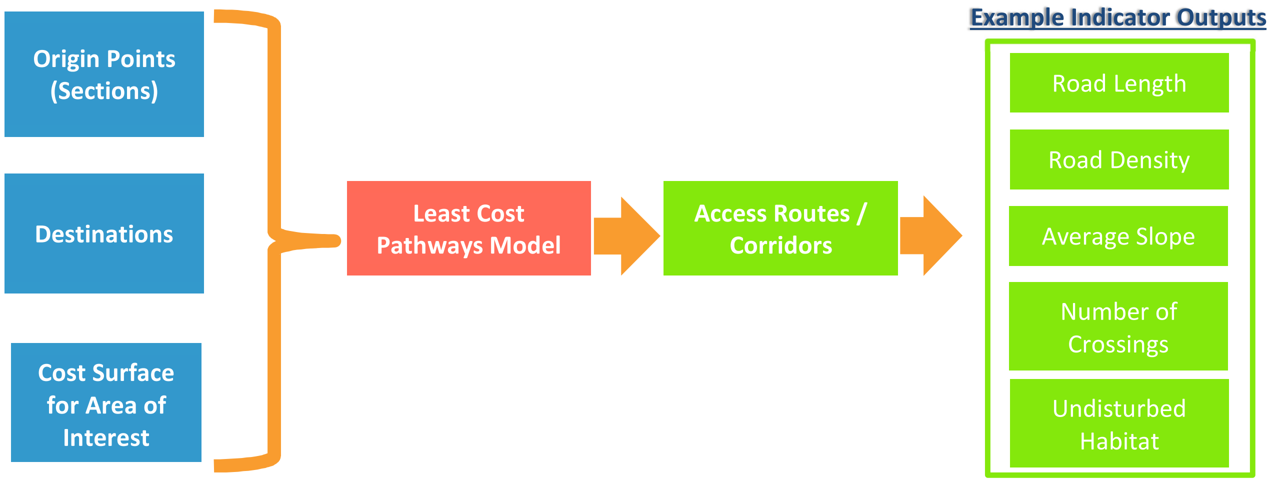


Figure 3-1: Diagram of the modeling framework

Primary inputs into this approach are the origin points (target resource extraction areas), destinations and a "cost surface" (Figure 3-1). A cost surface aggregates various routing variables and considerations across a management area (e.g. slope, wetland, crossings) in selecting corridors (Figure 3-2). The least cost pathways model then attempts to minimize overall cost in its selection of corridor locations to access target locations (Figure 3-2).

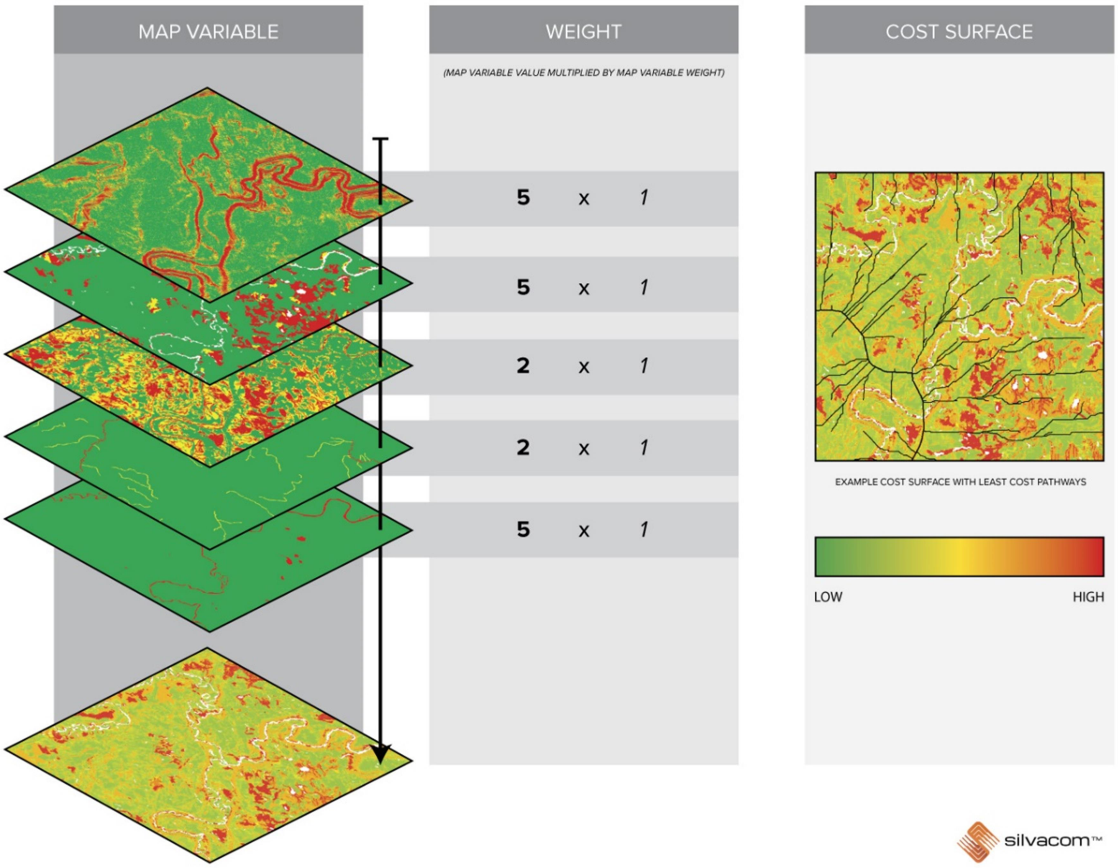


Figure 3-2: Schematic of the cost surface development and selection of least cost pathways

For this proof-of-concept analysis and Little Smoky / A La Peche corridor analysis, government and FLMF industry representatives collaborated to develop the cost surface input variables and outcome indicators for scenario comparison. Figure 3-3 provides an outline of the map variables that were selected along with their values, weights, and scores. Various scenarios were analyzed with the advisory group testing weighting of map variables, development pattern and corridor sequencing.

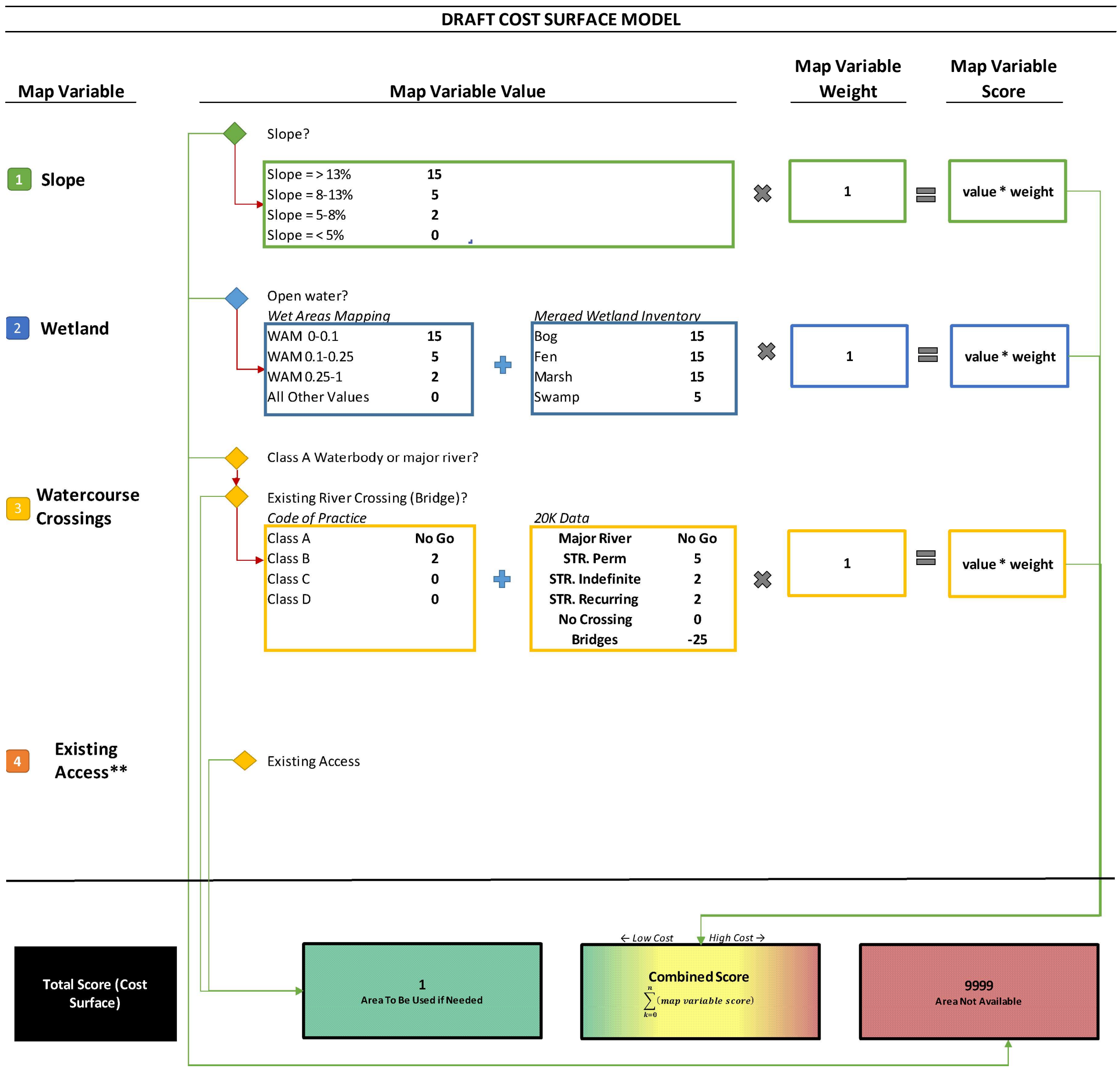


Figure 3-3: Schematic of the input map variable values, weights, and scores for the map variables utilized in the cost surface model

4. Proof of Concept Results

The proof-of-concept approach was used to:

- Help communicate, understand and build the process with government and industry representatives
- Build a model framework that is scalable & adaptable through a transparent, repeatable and data driven process
- Establish a benchmark to compare model outcomes and generate early signals on potential benefits at a large/range scale

It was determined during meetings that an area outside of the caribou range would be selected for a proof of concept. The area selected for the proof of concept was four townships considered "fully developed" with a high level of historical access from both the forestry and energy sectors. The selected area is located south of the caribou range (Figure 4-1) and utilized the same map variables, values, and weights set forth in the cost surface model (Figure 3-3). The intent of the proof of concept was to develop the model which will be scaled up to the range. During the development of the model, it was necessary to test a variety of scenarios to understand the workings of the model, its strengths and limitations.

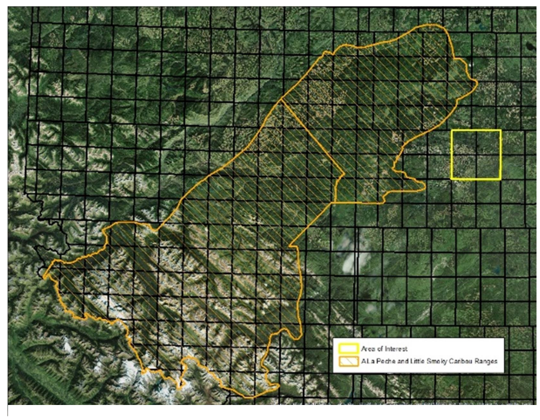
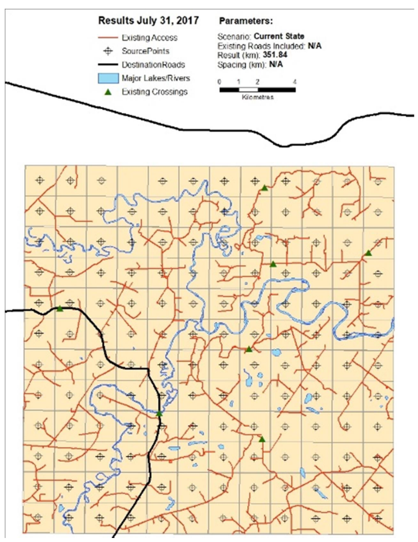


Figure 4-1: Map of the proof-of-concept area of interest

4.1 Baseline Analysis

The first set of analysis determined the existing road footprint in the four-township area using 20K base data and quantified the value of the output indicators for comparison. The first model iteration used locked-in access (permanent access) identified by the FLMF sub group and modeled least cost pathways to this access assuming a 1.6 km spacing of target resource areas to approximate conventional spacing. The results of this preliminary run demonstrated a 21% reduction in road length with the primary trade-off in number of crossings on perennial streams (Table 4-1). The results of this first run illustrate the potential of the model framework to streamline linear footprint. The results in this example do not represent well locations nor final road corridors as additional modeling and operational refinement, outlined in the RAMP planning process (Figure 2-1), are required but help illustrate the proof of concept of the model framework.

Table 4-1 Baseline analysis indicator results

<table>
<tr><th colspan="2">Existing</th><th>Model Iteration 1 (1.6 Km Spacing)</th></tr>
<tr><td colspan="2">


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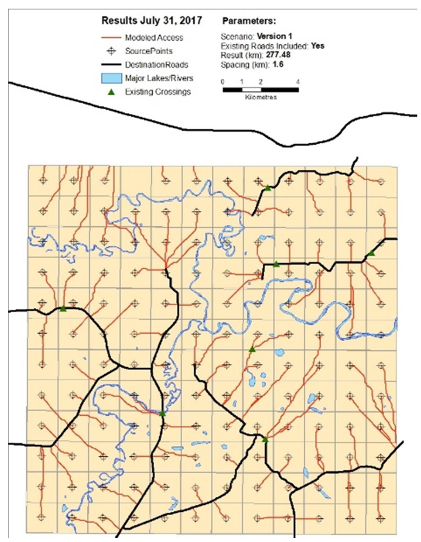
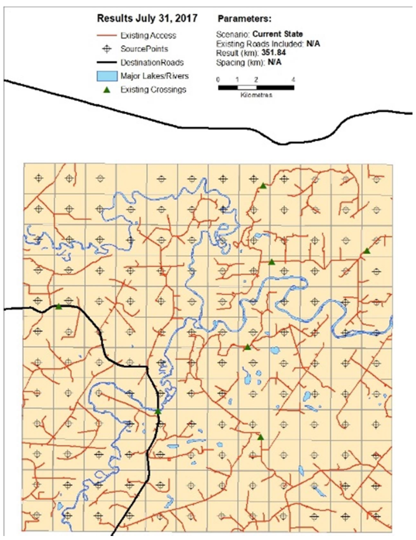
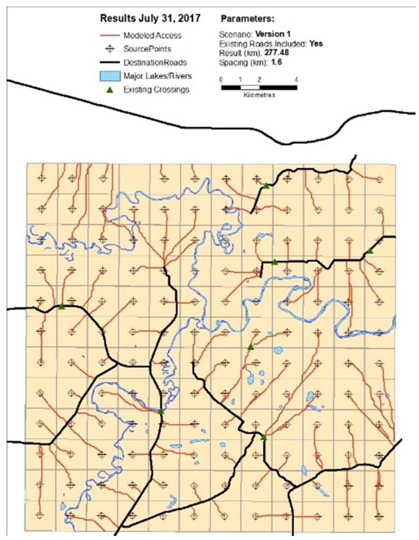
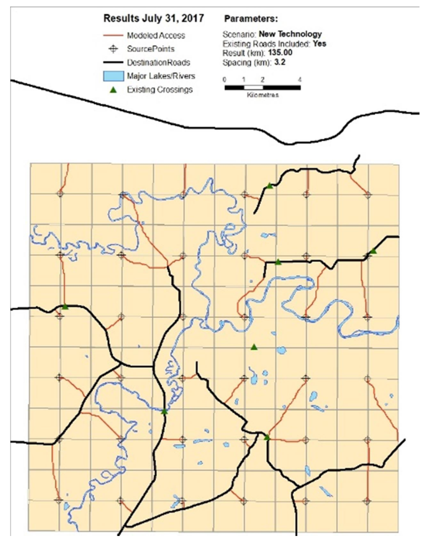


</td></tr>
<tr><th>Indicator</th><th>Existing Value</th><th>Outcome</th></tr>
<tr><td>Road Length (km)</td><td>351.8</td><td>277.5</td></tr>
<tr><td>Road Density (km/km^2)</td><td>0.93</td><td>0.73</td></tr>
<tr><td>Slope (Avg length (m) > 8%)</td><td>34.4</td><td>32.1</td></tr>
<tr><td>Wetland
(Total length km)</td><td>6.6</td><td>7.7</td></tr>
<tr><td>Crossings (Major Rivers, Perennial Streams)</td><td>4</td><td>19</td></tr>
<tr><td>% Undisturbed Habitat (using 500 m buffers on roads only)</td><td>28%</td><td>37%</td></tr>
</table>

4.2 Spacing Scenarios

The next set of analysis simulates a wider spacing (3.2 km) that may be achievable with modern drilling technology (e.g. horizontal drilling). In this proof of concept scenario road length is significantly reduced and undisturbed habitat significantly increased compared to the existing and modeled conventional spacing scenarios (Table 4-2). The results in this example do not represent well locations nor final road corridors as additional modeling and operational refinement, outlined in the RAMP planning process (Figure 2-1), are required but help illustrate the proof of concept of the model framework.

Table 4-2 Results of different target spacing

<table>
<tr><th colspan="2">Existing</th><th>1.6 Km Spacing</th><th>3.2 Km Spacing</th></tr>
<tr><td colspan="2">
</td><td>
</td><td>
</td></tr>
<tr><th>Indicator</th><th>Value</th><th>Outcome</th><th>Outcome</th></tr>
<tr><td>Road Length (km)</td><td>351.8</td><td>277.5</td><td>135.0</td></tr>
<tr><td>Road Density (km/km^2)</td><td>0.93</td><td>0.73</td><td>0.36</td></tr>
<tr><td>Slope (Avg length (m) > 8%)</td><td>34.4</td><td>32.1</td><td>36.2</td></tr>
<tr><td>Wetland (Total length km)</td><td>6.6</td><td>7.7</td><td>2.9</td></tr>
<tr><td>Crossings (Major Rivers, Perennial Streams)</td><td>4</td><td>19</td><td>7</td></tr>
<tr><td>% Undisturbed Habitat (using 500 m buffers on roads only)</td><td>28%</td><td>37%</td><td>66%</td></tr>
</table>

4.3 Additional Scenarios

A series of additional scenarios have been tested under the proof concept to help understand the workings of the model, the impact of the weighting of inputs and the effects of the timing and sequence of corridor development.

Runs were conducted adjusting the weight of the map variables individually at two times and five times their weight. Generally, in this four-township area, the road length was most sensitive to the weight of crossings.

The timing and sequence of corridor development were tested through various build-in and build-out strategies. The building in scenario selected the furthest origin points from each of the destination roads as starting points. From there the model builds the pathways in to the destination roads using the cost surface as a guide. The building out scenario selected the origin points close to the destination roads as starting points. From there the model builds the pathways out using the cost surface as a guide. These scenarios help establish the understanding of the need to consider a network approach in building corridors to reduce road length.

4.4 Corridor Analysis

Through the proof of concept analysis and the various model runs it became apparent that a single model run will not generate the desired outcome and that a series of iterative runs needs to be considered to identify common corridors that can be further delineated and refined with operational considerations (Figure 2-1). Overlaying model results on top of each other and generating a heat map is a powerful technique to help identify common corridors as shown in Figure 4-2.

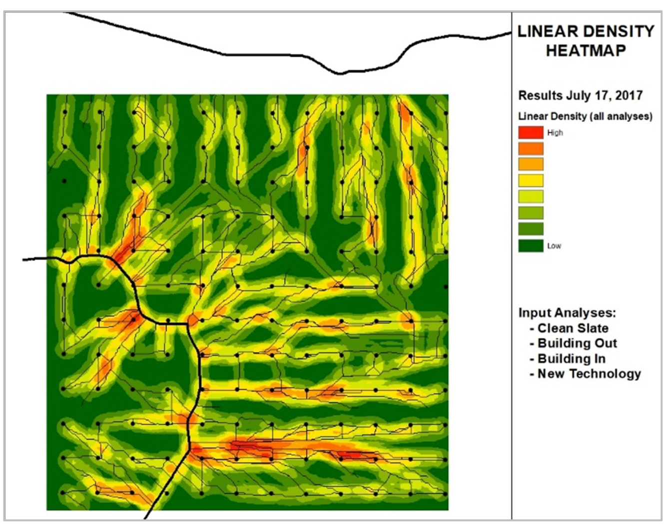


Figure 4-2 Density of common corridors

4.5 Proof of Concept Key Learnings

Key learnings from the proof-of-concept analysis include:

- A scalable and adaptable modeling framework has been developed which will allow for range or sub-range specific conditions to be considered in the analysis. Map variables in the cost surface can be added, removed or balanced for localized conditions and values;
- Increased well spacing with new technology presented the greatest opportunity for reduction in road footprint and caribou habitat disturbance within the scenarios tested to-date for these four townships;
- Timing and sequencing of development activities is an important consideration and can affect road corridor selection;
- Overlaying the various scenario outcomes highlights common/potential corridors (Figure 4-2). These corridors could present opportunities to further reduce the linear footprint by identifying existing redundant/non-required linear disturbances that could be restored; and
- An iterative process is required, founded with data and modeling, and further refined with operational input and considerations.

Limitations of the model:

- The proof-of-concept results are for a discrete four township area and as such the magnitude of change amongst scenarios may differ in other regions depending on the scale of the analysis and local topographic factors;
- The model is not intended to provide access locations for individual wells (e.g. tertiary access) however it provides a basis to locate primary and secondary access corridors which would be further verified with future operational ground truthing;
- The model cannot make all the access decisions but can be used as a tool for planners to examine tradeoffs in determining the location of primary and secondary access routes; and
- The scope of this analysis is limited to access corridors and as such does not consider specifications/requirements of other linear footprint such as pipelines. The designed modeling framework could, however, be adapted for a similar exercise for other forms of linear footprint.

5. Little Smoky / A La Peche Corridor Analysis

Following the completion of the proof-of-concept analysis the next step was applying the learnings and model framework to the Little Smoky / A La Peche range. Specifically, the analysis was completed on the Berland Smoky Regional Access Development Plan (RAD Plan) area which encompasses an area slightly larger than the Little Smoky / A La Peche range area outside of the parks (Figure 5-1).

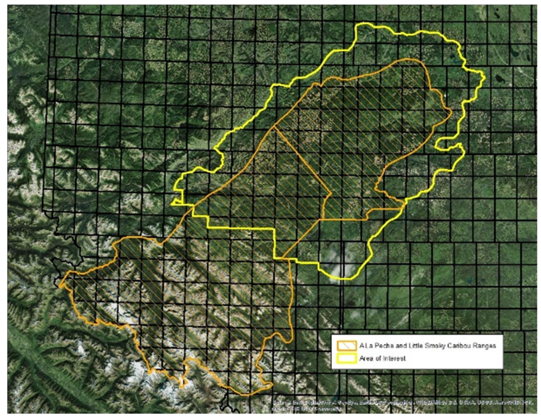


Figure 5-1 Map of the corridor analysis area

This area was selected to leverage and compare against previous access development planning (RAD Plan) and also to consider access entry points into the range. While the analysis was completed for the larger area, indicators were reported for just the range area within the RAD plan area.

5.1 Model Assembly

The same model framework that was used in the proof-of-concept was applied for this corridor analysis. The key inputs were:

- Origin points
  - Existing resource extraction / processing clusters
  - Future target resource extraction areas (center of 4 sections ~ 3.2 km spacing)
- Destinations
  - Fixed access routes identified in the FLMF road inventory identified as Class 1 & 2 roads (Figure 5-2)
- Cost Surface
  - A cost surface was created for the area following the same configuration applied in the proof-of-concept analysis (Figure 3-3)
  - The slope input data was enhanced with GoA LiDAR

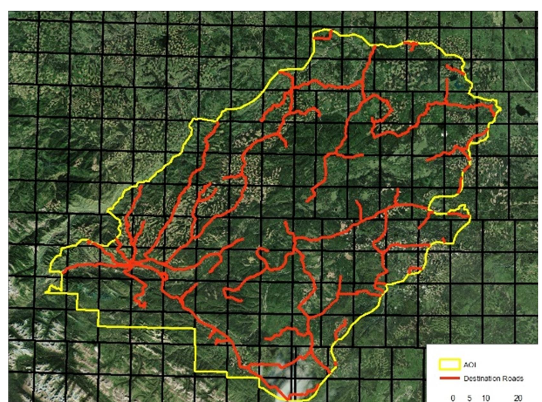


Figure 5-2 Map of fixed access corridors (FLMF Class 1 & 2 roads)

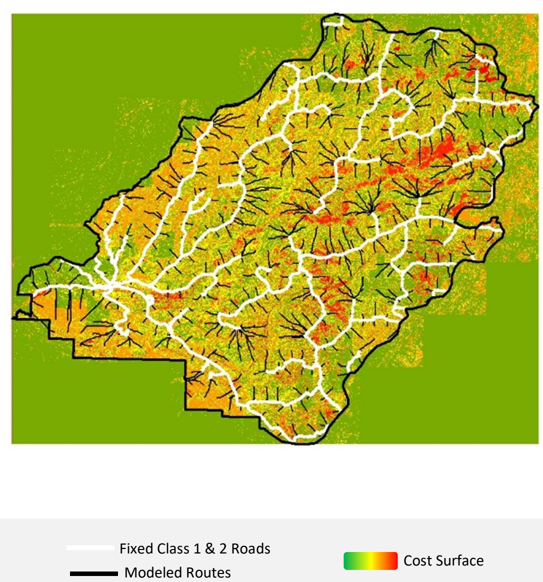
5.2 Model Simulations

As per the RAMP planning process (Figure 2-1) a series of iterative model runs were completed analyzing variable weighting, timing, and sequencing of development.

5.2.1 Model Iteration 1

Table 5-1 summarizes the model outputs for the first model run where cost surface variables are weighted equally.

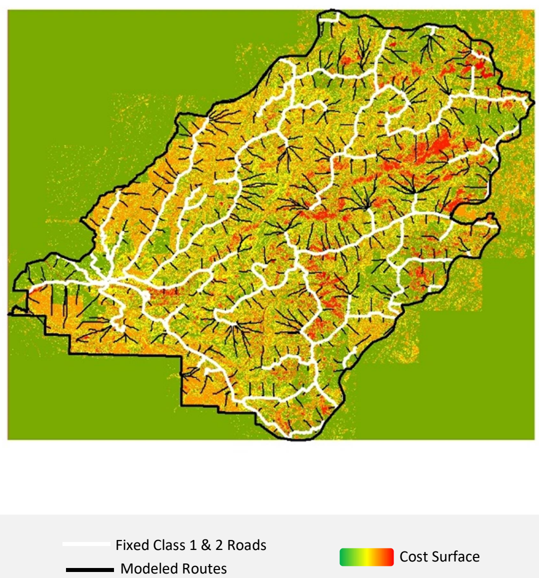
Table 5-1 Model Iteration 1 results

Indicator	Fixed Class 1 & 2 Roads	Modeled Corridors	Total	Map	
Total km	588	1,278	**1,866**		
Density (km/km2)	0.12	0.27	**0.39**		
Slope >8% (km)	147	285	**432**		
Slope > 13% (km)	47	110	**157**		
Slope Average (%)	6.1	N/A	**6.3**		
Slope Avg Length 8-13%	40	N/A	**39**		
Slope Avg Length >13%	54	N/A	**60**		
Slope Avg Length >8%	73	N/A	**75**		
Crossings (#)	14	61	**75**		
Length in Wetland (km)	12	31	**42**	Undisturbed Habitat	**65%**
Disturbed Habitat (%)	12	24	**35**		

5.2.2 Model Iteration 2 – Crossings x2

Table 5-2 summarizes the results of a model run where the weight of crossings in the cost surface model is doubled.

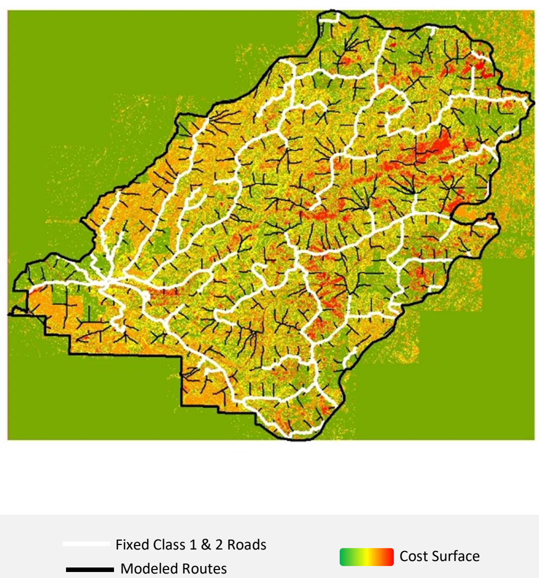
Table 5-2 Model Iteration 2 – Crossings x2 results

Indicator	Fixed Class 1 & 2 Roads	Modeled Corridors	Total	Map
Total km	588	1,278	**1,866**	
Density (km/km2)	0.12	0.27	**0.39**	
Slope >8% (km)	147	284	**431**	
Slope > 13% (km)	47	110	**157**	
Slope Average (%)	6.1	N/A	**6.3**	
Slope Avg Length 8-13%	40	N/A	**39**	
Slope Avg Length >13%	54	N/A	**60**	
Slope Avg Length >8%	73	N/A	**75**	
Crossings (#)	14	60	**74**	
Length in Wetland (km)	12	31	**43**	Undisturbed Habitat **65%**
Disturbed Habitat (%)	12	24	**35**	

5.2.3 Model Iteration 3 – Build In

Table 5-3 summarizes the outputs from an iterative build in strategy where resources are accessed at the furthest point from existing fixed access routes first and the subsequently built inwards in iterative stages, networking routes together.

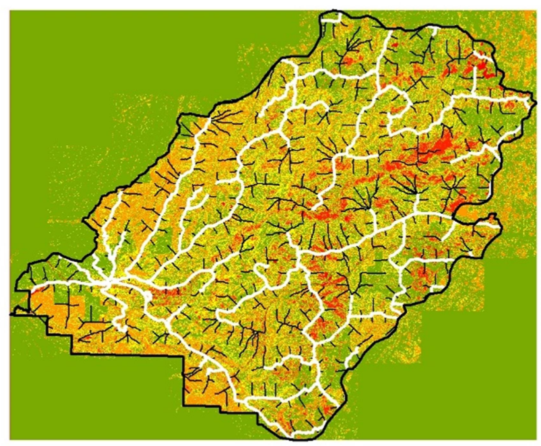
Table 5-3 Model Iteration 3 – Build In

Indicator	Fixed Class 1 & 2 Roads	Modeled Corridors	Total	Map	
Total km	588	1,119	**1,707**		
Density (km/km2)	0.12	0.24	**0.36**		
Slope >8% (km)	147	255	**402**		
Slope > 13% (km)	47	100	**147**		
Slope Average (%)	6.1	N/A	**6.3**		
Slope Avg Length 8-13%	40	N/A	**39**		
Slope Avg Length >13%	54	N/A	**61**		
Slope Avg Length >8%	73	N/A	**79**		
Crossings (#)	14	53	**67**		
Length in Wetland (km)	12	31	**42**	Undisturbed Habitat	**66%**
Disturbed Habitat (%)	12	22	**34**		

5.2.4 Model Iteration 4 – Build Out

Table 5-4 summarizes the outputs from an iterative build out strategy where resources are accessed near existing fixed access routes first and the subsequently built outwards in iterative stages networking routes together.

Table 5-4 Model Iteration 4 – Build Out

Indicator	Fixed Class 1 & 2 Roads	Modeled Corridors	Total	Map
Total km	588	1,087	**1,675**	
Density (km/km2)	0.12	0.23	**0.35**	
Slope >8% (km)	147	257	**404**	
Slope > 13% (km)	47	100	**147**	
Slope Average (%)	6.1	N/A	**6.4**	
Slope Avg Length 8-13%	40	N/A	**40**	
Slope Avg Length >13%	54	N/A	**60**	
Slope Avg Length >8%	73	N/A	**79**	
Crossings (#)	14	54	**68**	Fixed Class 1 & 2 Roads; Modeled Routes; Cost Surface
Length in Wetland (km)	12	31	**42**	Undisturbed Habitat **67%**
Disturbed Habitat (%)	12	21	**33**	

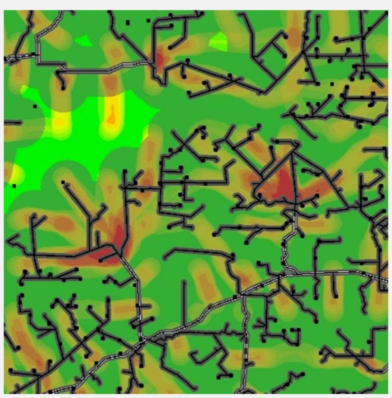
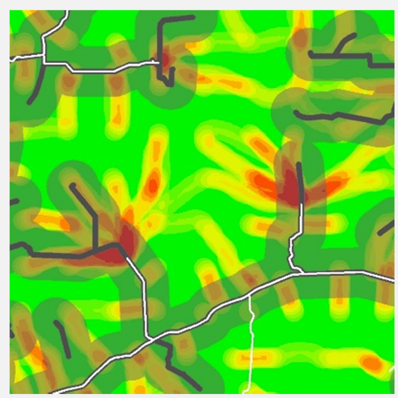
5.3 Corridor Analysis – Example Area

A key learning in the proof of concept analysis was that using analytical tools such as a density analysis can highlight common corridors between different model runs. This identifies potential key pathways to consider for an access corridor.

The route outputs of the various model runs were combined through a density analysis to identify corridor hotspots for the study area. For illustrative purposes and to further examine the outcomes, a sub area was selected for further comparative analysis.

Table 5-5 provides a comparison of preliminary RAMP corridors with existing roads and the RAD plan. Each map displays a heat map in the background (red to green) displaying the results of the density analysis and highlighting potential common corridors from various model runs. There are similarities with the RAMP corridors, existing footprint and the RAD plan however it is evident the scope of the RAD plan was different. RAMP considers access to long term future resource covering close to 95% of the area as represented by a theoretical 1,600 m buffer around access corridors. The RAD plan without extensive tertiary access development may have resulted in “stranding” resources. The existing footprint also has near complete theoretical access to resource in this example (94%) but does with 87% more road in comparison to the example RAMP corridors.

Table 5-5 Corridor analysis maps

Existing	RAMP Corridors	RAD Plan Corridors
		
Fixed Class 1 & 2 Roads; Existing roads; 200 m Access Corridor; 1,600 m Buffer; RAMP Density Analysis		
490 Km	262 Km	113 Km

6. Next Steps

Alberta is taking a leadership position in addressing caribou population recovery. In support of achieving caribou habitat objectives, the Regional Access Management Plan (RAMP) was initiated to develop a process and model framework to identify a strategic access corridor plan that provides access to resources, minimizes active footprint while maximizing undisturbed caribou habitat.

Through the proof-of-concept analysis and preliminary Little Smoky/A La Peche corridor analysis, it has been demonstrated that RAMP can be a key tactic to minimize industrial footprint while strategically aligning access to resources. Development of integrated access plans in theory should be completed prior to any development and directed by higher order land use and sub-regional plans. However in areas like the Little Smoky A La Peche this is not possible as access development has been in practice for decades. The complexity of overlapping tenure ownership and existing infrastructure requires an on-going, process which should include the ability to reconcile existing access, identify reclamation needs, maximize resource accessibility and analysis of tradeoffs between new and existing access requirements.

Next steps include the following:

a) Formalize the development of a pilot project for the RAMP area (Little Smoky / A La Peche caribou ranges) to move into implementation of an access planning process
b) Definition of the regulatory process for planning, approving, implementing, and monitoring corridor development.
c) Formalize a governance model to guide industry and GoA in the implementation of the pilot project including mandatory integrated land management (ILM).
d) Industry to develop recommendations on how to proceed to implementation that builds on all access planning work to date in the Little Smoky / A La Peche caribou range by Nov 30, 2017

Appendix A. Draft Regional Access Management Planning Process