Third Party Review of the Resort Centre ASP Amendment Environmental Impact Statement

FINAL REPORT

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Executive Summary

As per the Town of Canmore's Environmental Impact Statement (EIS) Policy, changes to existing Area Structure Plans require an Environmental Impact Statement to be completed by the applicant, and this EIS must be reviewed by an independent third-party reviewer chosen by the Town of Canmore. The current landowners of the Resort Centre ASP have signaled their intention to the Town of Canmore to submit an ASP amendment whereby the 110 hectares of Resort Centre lands currently zoned for a golf course would instead be developed into additional residential, commercial, resort accommodation, and supporting recreational spaces, as well as the addition of up to 465 units and 300,000 square feet of commercial development within the ASP area. As part of the application to amend this ASP, the developers completed an EIS, and Fiera Biological Consulting Ltd. was retained by the Town of Canmore to complete the required third-party scientific review on the EIS.

This review found that the Resort Centre EIS evaluated potential impacts by examining possible changes to existing conditions based on the output of Resource Selection Function (RSF) models which examine an animal's habitat selection, not their movements. Because of the ASP's immediate adjacency to designated wildlife-movement corridors, we argue that an RSF approach is not the correct analysis for this EIS, and we review how RSF models are movement-independent and are only one component to a more complex and required connectivity analysis exploring animal *movement*. We explain why connectivity analyses are required in a more complete and well-informed EIS addressing landscape movements by wildlife, and whether movement corridors could be directly or indirectly implicated by adjacent development. We discuss how RSF layers could inform a connectivity analysis by serving as a potential resistance surface therein, and we discuss the scientific appropriateness and advantages of our recommended approach.

For the RSF models presented in the EIS, we discuss analytical anomalies we found that made them difficult to assess or contextualize ecologically. We noted discrepancies in model output that implicated the validity of the land cover data used for this EIS, and thus by extension the RSF output. Specifically, we found marked differences in the age of the animal telemetry data versus the age of the land cover data, and we were unable to acquire clarity on how animal-telemetry data were linked to contemporary land covers to generate wildlife-habitat relationships. We also identified missing components of the statistical methods, namely the absence of any structured hypotheses to support the inclusion and comparison of 74 candidate wildlife-habitat models. In the absence of these hypotheses as critical context, we argue that the RSF-model output cannot be evaluated or placed within the framework of impact assessment. As a result, we caution that considerable uncertainty is contained within the RSF-model output used to rationalize mitigations proposed in this EIS.

With respect to understanding the potential impacts of the development on wildlife, we approve of the proponent's use of scenario modeling, but we found their approach to be incomplete and not strongly linked to an assessment of how different development scenarios might impact existing conditions for wildlife movement. Of the five development scenarios examined in the EIS, only one scenario was examined with reference to expected increases in human recreation, and in this one examination, development and human-use levels were examined independently of each other, despite being inextricably linked. Further, there were tenuous assumptions that doubling human population density would only result in small reductions to wildlife-habitat quality, and that proposed access-management mitigation would be 100% effective, which we argue is overly optimistic. Regarding the EIS's recommendation to fence the entire development, we caution that other development scenarios could have been examined to better articulate and assess potential indirect effects from the development specifically related to fence positioning, and we discuss these in some detail. We also discuss how modeling, mitigation, monitoring, and adaptive management should be better linked together in an implementation framework that would provide a more viable way forward for this ASP amendment application.

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1.0 Introduction

1.1. Town of Canmore EIS Policy & Process

In September 2016, the Town of Canmore approved an Environmental Impact Statement (EIS) Policy. The stated purpose of the policy is to ensure that an environmental impact assessment "provide sufficient information to a decision making authority in order to make an informed decision on the proposal before it. " (Town of Canmore 2016, pg. 1). The policy goes on to describe the process for undertaking an EIS, including the development of a Terms of Reference (TOR), and a description of the role of the third party reviewer. Given that the EIS policy is new, it is important to understand the process and timelines that were followed for this third-party review, and specifically, the level of involvement from Fiera Biological Consulting Ltd. in providing an independent and science-based critique of the Resort Centre EIS that was submitted to the Town of Canmore by Golder Associates Ltd. (Golder) and Quantum Place Developments (QPD).

In October 2016, the Town of Canmore issued a Request for Proposals (RFP) for a third party review of the Resort Centre EIS. In the RFP, it was noted that the Town expected that the EIS for the Resort Centre would be delivered to the Town for review by the end of October, along with the submission of the ASP amendment. In early November 2016, Fiera Biological Consulting Ltd. (Fiera Biological) was retained by the Town of Canmore to provide a third-party review for the Resort Centre EIS. Fiera Biological's role was to act as a third-party reviewer evaluating the scientific validity of the Resort Centre EIS and, in doing such, were required to suggest improvements or alternatives to improve upon science-based methods, results, and recommendations of the EIS. As per our own TOR with the Town of Canmore, rather than only evaluating a final draft of the EIS, it was required that we review draft components of the EIS in advance of a final submission with the intent of avoiding a situation where major revisions would be required to a lengthy and completed document. The intent was to maintain a third-party independence, with the ultimate goal of avoiding, if possible, a final submission that in the opinion of the third party reviewer, did not meet the TOR set forward by the Town.

As per the Town's EIS Policy, the first step in the third party review was to provide input into the Resort Centre TOR, which had been previously developed by the Town. Specifically, the EIS was to provide science-based information and advice to Town Council to inform decisions related to the Resort Centre ASP amendment; namely, the direct impacts of development within the Project Boundary, as well as the indirect and cumulative impacts of the development within a larger regional study area defined in the EIS as the Bow Valley Corridor from approximately Dead Man's Flats to the Banff Park gate. It was our opinion that the Town's TOR effectively articulated the need to examine both the immediate effects of the project within the proposed development footprint, and also a broader examination of ecological sensitivities in adjacent lands within the framework of cumulative effects. We felt this cumulative effects approach was valuable considering that the Bow Valley is arguably the most heavily developed valley in North America that still retains a full complement of large, native mammal species, and thus, that landscape adjacency and the maintenance of functional proximate wildlife corridors is important. Therefore, we continually stressed the importance of the Bow Valley as a key movement corridor for wildlife, and that wildlife movement be considered as the fundamental component of cumulative effects in evaluating the direct and indirect impacts of the proposed project. We submit that the terms of reference for the Resort Centre EIS effectively captured this in requesting specific analyses addressing;

> *…human-use impacts on wildlife populations; an evaluation of whether the form of the development can be accommodated given any identified ecological sensitivities; and an analysis of the cumulative impacts of the proposal considering the impacts of adjacent development.* (TOR, Sections 5a, 5c, and 5d)

Throughout the review process, Fiera Biological made every effort to provide a scientifically objective critique of the Resort Centre EIS and interact with the Town and with Golder directly, but while also maintaining an independence that is critical to the review process. As such, it is important for the reader to note the following as it relates to our involvement in the development of the Resort Centre EIS:

1. While this review was an iterative process, our involvement in providing this review in no way implies a collaboration between Fiera Biological, QPD, and Golder, and it was entirely at the discretion of Golder and QPD to accept or rebut any editorial comments or suggestions made to them by Fiera Biological throughout the review process;
2. Fiera Biological had no direct input into, or final say on, any content submitted by Golder or QPD as part of the development of the Resort Centre EIS, and all content of the EIS was developed at the sole discretion of the authors of the EIS;
3. Fiera Biological limited its review to the validity of the scientific methods used to assess impacts, and subsequently, the validity and feasibility of the proposed mitigation in light of the predicted impacts. Where we deemed impact assessment to be incomplete, inappropriate, or questionable, we did not offer suggestions for the refinement of mitigation strategies. One of our main concerns with the Resort Centre EIS is that it did not appropriately define existing conditions for wildlife movement, nor did it fully explore the potential impacts of the development on existing movement conditions. Mitigation recommendations must follow defensible impact assessments, and we argue herein that these impacts have not been appropriately or comprehensively assessed. Consequently, we deemed it inappropriate and premature to refine the EIS's suggested mitigation, let alone suggest alternatives.

1.2. EIS Review Timing & Context

It is important to note here that irrespective of the review process laid out by the Town's policy, a draft version of the EIS for the Resort Centre had already been written prior to our involvement in reviewing the terms of reference for the EIS. In part, this was a function of the Town of Canmore's EIS Policy having only recently being approved by Town Council, the timing of which did not correspond well with the on-going work and desired timelines of QPD with respect to submission of the Resort Centre ASP amendment. We found that this existing draft EIS and it's *a priori* methods and focus, notably dating back >5 years to similar applications, weighed heavily on the direction of this process and on the time it took to reach this final review, which was approximately six months. Despite these temporal discrepancies, a first draft of the EIS was submitted to the Town for a formal review on November 23, 2016.

Upon reviewing the first draft of the Resort Centre EIS we noted a lack of detail regarding the proposed development and associated environmental impacts, an absence of a scientifically valid evaluation of how the development might directly (i.e., through habitat loss) and indirectly (i.e., through increased noise, light, and human recreation) impact baseline conditions related to wildlife movement within the development area and adjacent wildlife corridor, and insufficient details on how the proposed mitigation and associated adaptive management would be implemented to reduce or eliminate residual impacts. Our most notable concern with the first draft of the EIS was related to the lack of any analysis to quantify and describe existing conditions related to animal movement within the project boundary and the adjacent wildlife corridor, which we argued was a fundamental requirement for the assessment of potential impacts related to the Resort Centre amendment application.

Subsequent to our initial review, we were asked to participate in an in-person meeting with Golder and QPD to discuss our review, and to allow Golder and QPD to ask questions to clarify the issues of concern that we had raised through the third-party review process. In that meeting, we re-iterated our major concerns, primarily that existing conditions for wildlife movement had not been properly evaluated, and as a result, the impact assessment was incomplete. A central focus of this meeting included a discussion about how the EIS could be revised to better address this gap. In late February 2017, a second version of the Resort Centre EIS was submitted to the Town of Canmore, and this re-submission is the subject of the review contained herein.

Throughout this EIS review process, we have reiterated that the EIS should address wildlife movement through an analysis of habitat connectivity to examine how the proposed amendment might affect patterns of wildlife movement. At no time did we implicate corridor designation, location, width, or the like. We clarified that the baseline patterns of animal movement could be impacted by the development in three ways; (a) directly through changing an unfenced golf-course area into a fenced community, (b) indirectly through increased light and noise from the new community, and (c) directly through an increase in human use of the existing wildlife corridor.

1.3. Scope & Objectives of the EIS Review

As per the direction received from the Town of Canmore, the role of the third party reviewer in the evaluation of the Resort Centre EIS is to:

- Review the development proposal for amending the ASP;
- Assist Town staff in preparing the Terms of Reference for the EIS;
- Review and identify additional relevant data and literature related to the proposal;
- Review and identify additional criteria for evaluation of the proposal;
- Evaluate the analysis of impacts of the proposal including cumulative impacts, and alternative development options;
- Evaluate proposed mitigations, significance of the residual impacts and recommendations;
- Identify additional potential mitigation strategies;
- Review and identify additional monitoring or study requirements.

Central to this third party review is to ensure that the Resort Centre EIS meets the following conditions:

1. That the EIS is complete, as per the project-specific Terms of Reference;
2. That the scientific basis for the assessment of impacts is appropriate;

3. That the conclusions drawn with respect to impacts appropriately reduce uncertainty related to how the proposed project will impact Valued Environmental Components (VECs);
4. That the mitigation and monitoring proposed is appropriate in light of the anticipated impacts.

It is important for us to note here that the terms of reference for this EIS contained a statement that has caused notable confusion and debate throughout the review process, specifically:

> *“The scope of the EIS will not include the functionality of the wildlife corridors as this is under the authority of the Province under the direction of the NRCB Decision; however, wildlife corridors are a valid municipal planning issue and the environmental review will need to consider development proposed adjacent to wildlife corridors and habitat patches.”*

This statement simultaenously indicates that an evaluation of corridor functionality is both required and not required. But beyond the obvious confusion of this statement, also at issue here is the phrase “functionality of the wildlfe corridors.” Within the context of this review, our interpretation of “corridor functionality” includes the effectiveness of the existing willife corridor to facilitate wildlife movement through the Town of Canmore and the Bow Valley Corridor. Specifically, we refer to corridor functionality as an understanding of the existing conditions of wildlife movement, and how the proposed changes to the Resort Center ASP would affect existing patterns of movement by;

1. Fencing the existing unfinished golf course lands and effectively removing these lands from augmenting the existing wildlife corridor;
2. Redistributing currently approved unit densities into the unfinished golf-course lands, and;
3. Post-development effects of increased light, noise, odours (etc), and human recreation on wildlife movement through the adjacent willife corridor.

We are not implicating the legal boundaries or spatial positioning of the existing wildlife corridors, nor are we suggesting a re-designation of corridors based on this EIS. Rather, we maintain that the EIS must contain an assessment of the current conditions of *wildlife movement* through the project boundary and wildlife corridor given existing ASP approvals, and how the propsed ASP amendments might alter these current conditions.

2.0 Existing Conditions and Impact Assessment

This section includes a detailed scientific review of the impact-assessment methods used to describe existing conditions (i.e., baseline conditions, which are existing conditions given existing ASP approvals), and whether the methods employed are the most scientifically appropriate to accurately articulate whether the proposed development is likely to cause deviations from existing conditions.

Section 2 at a glance. The EIS based its assessment of existing conditions and potential impacts on Resource Selection Function (RSF) models which examine an animal's habitat selection, not their movements. Because of the adjacent wildlife-movement corridor, we argue that existing conditions should be assessed instead using a habitat connectivity analysis and we discuss how this differs from an RSF approach. We also raise cautions with the methods used to develop the RSF models. Specifically, we review discrepancies between the dates animal telemetry data were collected versus the dates land cover layers were created, and how this has potentially marked implications for the RSF validity and uncertainty. We also note missing components in the habitat models that made them difficult to interpret ecologically, and thus hard to contextualize regarding impact assessment. When these models were used to examine potential development scenarios, only one of five presented scenarios was fully examined, leaving much uncertainty in comparing the presented options. We also note some short-falls in documenting other environmental variables and suggest which of these might require additional assessments moving forward.

2.1. How Were Existing Conditions Measured?

One cannot predict potential ecological impacts associated with a proposed development without first documenting existing, reference, or baseline conditions against which to contextualize impacts. A clear documentation of existing conditions allows a pre-development understanding of how close a system might already be to different ecological thresholds. If thresholds are not implicated, then there may be some resilience in a system to cope with further impacts; however, if existing conditions indicate that thresholds are already close to being triggered, then even low-level impact might trigger a cascade of effects through a system, and ecological impact could be marked. This understanding of existing conditions is crucial to offering evidence-based mitigation techniques, as more aggressive techniques might be required if ecological thresholds are known to be implicated, or perhaps no mitigation is required if a system is known to be resilient. But this knowledge must be acquired before development occurs, and cannot be abdicated to “careful phasing” or monitoring during development. Also, the most important metrics or indicators for which to measure existing conditions must be clarified in advance.

In the case of the Resort Center EIS, there was little agreement reached on what to measure that would best indicate existing conditions. As we have noted earlier, our interpretation was that existing conditions of *wildlife movement* should be examined within the context of the proposed ASP changes; however, the proponent’s position was that existing corridor functionality could be measured through an analysis of wildlife *habitat selection* instead. It therefore becomes important to clarify how these two approaches are different and how either one might be more or less relevant to the Resort Center EIS with respect to providing a germane understanding of existing conditions.

The Resort Centre EIS documented existing conditions using Resource Selection Function (RSF) models, which examine an animal’s habitat selection, not their movements. We argue below that an RSF approach is not the most appropriate analysis for the Resort Center amendment application, which in our opinion should have focused on patterns of wildlife *movement* within the project boundary and adjacent wildlife corridors and how the proposed ASP amendments might affect current patterns of animal movement. We argue these conditions could be affected by (a) the proposed redistribution of currently approved units into the unfinished golf course where current development approvals do not exist, (b) the fencing and development of the unfinished golf course effectively removing existing open space from augmenting the current wildlife corridor, and (c) an overall increase in unit densities and the subsequent increased noise, light, odours, and human recreation penetrating into the existing wildlife corridor. Given this critique, we feel it is important to provide the reader with background that will allow them to understand the contrast between habitat selection (as measured through RSF models) and wildlife movement (as measured through connectivity models), and to better appreciate the recommendations we make herein for improving the Resort Center EIS.

Are RSF Models Appropriate?

One of the most comon uses of wildlife radio-telemetry data is the creation of RSF maps, denoting areas where there is a relatively high probability of an animal selecting habitat. RSF models are generated by examining the proportional use of an area (or resource unit) with respect to its availability, and the model’s output is typically a heat map indicating an areas’ “hot spots” for a species’ probable occurrence. Within the correct context, RSF model outputs are very informative, as it is often important to know what areas of a managed landscape a species would most likely occur within; however, it is often equally or more important to understand how an animal might arrive at these locations; because although high-quality habitat might exist, an animal may not be capable of reaching its location. The data used to inform RSF models most often are not movement data, usually because there is an inability of the researcher to discriminate movement locations from other behaviours, and thus the subsequent RSF models is movement-independent. This occurred in the Resort Center EIS. The RSF models developed to assess impacts to focal wildlife species in the Resort Centre EIS were created using a relatively small sample of wildlife-telemetry data (e.g., 5 grizzly bears over 8 years, etc., see Section 2.2. herein for more details), preventing the discrimination of movement data from non-movement data.

For most studies where RSF models are developed and used to inform our understanding of species ecology, the output data is typically movement-independent, and this is due to the low temporal resolution of telemetry relocation data and the inability of separating data into "movement-only" data. Advances in GPS-based data collection and in analytical techniques have facilitated incorporating animal movement into habitat selection studies (Fortin et al. 2005, Forester et al. 2009, Potts et al. 2014), but this is not common, as RSF models are typically not employed as movement models. Some forms of RSF models involve constraining availability of selection to a single step by the animal (straight line connecting two sequential relocations; Nathan et al. 2008) making the RSF more movement-like, and additional advances of this method, such as step-selection functions (Fortin et al. 2005, Avgar et al. 2016) and path-selection functions (Cushman and Lewis 2010), define GPS relocations temporally, allowing inclusion of spatially and temporally dynamic variables thought to influence an animal's space use, greatly expanding the applicability of RSFs. These techniques, however, were not used in the Resort Center EIS. These more advanced methods are especially relevant and useful for monitoring large, free-roaming mammals and serve as a good example of where the traditional point selection RSF approach is insufficient in situations where the primary concern is animal movement, like in the Resort Center context. The more advanced RSF approaches (i.e., step-selection functions or path-selection functions) provide a much more robust and powerful model of animal habitat use, and can serve as an important input into a connectivity analysis, but of themselves, RSF models are not an assessment of movement.

Connectivity Models are More Appropriate

Connectivity analyses and models are the "next step" in a complete and well-informed analysis of landscape use by wildlife, and are also highly informative in impact assessments where movement corridors are directly or indirectly implicated, such as the Resort Centre EIS. Connectivity is defined as "the degree to which the landscape facilitates or impedes movement among resource patches" (Taylor et al. 1993), or more simply as "the ease with which individuals can move about within the landscape" (Kindlmann and Burel 2008). Ecologists and land managers model and measure connectivity because habitat loss and fragmentation reduces landscape connectivity, which leads to isolation of individuals or populations via reduced foraging, dispersal, reproduction, and/or migration movements (Lindenmayer and Fischer 2006). Maintaining or restoring connectivity is thus necessary for persistence of local and peripheral populations, and a measure of connectivity is necessary for assessing the capacity of fragmented landscapes to support viable populations (Moilanen and Hanski 2001).

When properly designed and specified, a connectivity model can asses "baseline" connectivity for an existing corridor, aide in identifying new corridors, can determine the location of isolated habitat patches, and can identify where pinch-points may exist within previously designated corridors (i.e., areas where wildlife movement is constricted to a narrow corridor). These models can also identify locations where development impacts might be more significant in constraining movement. In the context of Resort Centre where corridors and habitat patches are designated, connectivity models can provide a quantifiable impact potential of a proposed development next to an identified corridor; in other words, connectivity can be modeled before and after a hypothetical land development, and the before and after measures of connectivity can be compared to suggest whether an existing corridor should still function post-development, or at what level of development we should expect functionality to decline. Or perhaps most importantly, a connectivity model could suggest *a priori* whether the existing corridor currently functions and how close existing conditions already are to reaching an impact threshold beyond which functionality declines. This is the primary assessment tool we argue is absent from this EIS.

There are numerous approaches to modelling connectivity (reviewed in Singleton and McRae 2013, Wade et al. 2015, conservationcorridor.org, corridordesign.org); however, the most common approaches are based on the concepts of landscape permeability, and use a “resistance layer” to contextualize an organism’s ability or willingness to cross a particular environment, the physiological cost of moving through a particular environment, and/or the reduction in survival for moving through a particular environment (Zeller et al. 2012). Ultimately, a resistance layer (aka friction layer, impedance layer) can be thought of as a travel surface that recognizes that animal movement is influenced by the varying conditions and features an individual encounters as it moves across the landscape (Adriaensen et al. 2003). Resistance layers are most commonly developed based on expert knowledge or by using an RSF, each of which has certain limitations (Zeller et al. 2012). Importantly, resistance by itself does not tell the whole story of connectivity; the spatial arrangement of resistance values and the links that they form, as well as the pattern and configuration of resources or habitat patches must be considered together to properly assess connectivity (Beier et al. 2008, McRae et al. 2008).

A properly designed resistance layer, or multiple resistance layers to account for variations in species-specific landscape interactions, is the main input to a connectivity model, which then models or predicts movement across the landscape. Various examples of connectivity analysis outputs are shown in Figure 1 and Figure 2 herein, and can be developed at whatever scale is appropriate (i.e., provincial, regional, local, or even site-level). Connectivity models are integral in scenario analysis to both rank the importance of core areas of habitats, the linkages between them, and how these components change under different scenarios over time.

RSFs as Resistance Layers in a Connectivity Model

RSFs are commonly incorporated as components of connectivity analyses, since they are a common analysis product and provide the “where” component for describing an organism on the landscape. Historically, it has been common practice to equate resistance to habitat quality or selection and to simply use the inverse of an RSF model output to define resistance (Wade et al. 2015), despite no generally accepted or standardized method for doing so (Beier et al. 2008, Zeller et al. 2012). This approach has been critiqued repeatedly (e.g., Beier et al. 2008, Kadoya 2009, Zeller et al. 2012, Singleton and McRae 2013, Wade et al. 2015, Abrahms et al. 2016), and there is a strong consensus that describing and predicting “where” something is does not equate to describing how it got there or how it moves between other places. Additionally, there is a consistent lack of validation of movement models based on RSFs as resistance surfaces (Wade et al. 2015, Abrahms et al. 2016).

Specifically, using an RSF to define resistance relies on the assumption that animals make movement decisions based on the same preferences they use in selecting habitat. This may be a reasonable assumption if considering movements solely within resource patches or if a species is non-motile or of low vagility and is constrained to suitable habitat for its lifetime. However, for any species driven by something other than resource selection during movement events (e.g., disturbance, avoidance, predator-prey interaction, territoriality, physical barriers, migration, dispersal, mating) then resource selection is not appropriate for estimating resistance values (Singleton and McRae 2013, Zeller et al. 2012). For example, some data suggest that individuals travel faster through habitats of low suitability, and have slower movements (assumed to have higher costs) in preferred habitats (Palomares 2001; Dickson et al. 2005). Species movement becomes even more complicated in human-dominated or disturbed landscapes as individuals can both be attracted to and avoid low quality habitat (Chetkiewicz and Boyce 2009). For example, linear features, such as roads, trails, or seismic lines, may be poor or dangerous habitat, but may be attractive as efficient movement corridors between resources (Latham et al. 2011). Ultimately, determining what the goal of the animal’s movement is will determine if an RSF can be used to define resistance – if an individual remains within a single resource area, habitat use and connectivity will be closely related, but if moving between areas (e.g., resource patches, dispersal, migration) an RSF will not reflect movement.

Despite the known limitations of RSF models for representing movement and landscape connectivity, they are still sometimes used for developing a resistance surface. When using a selection function as input for a resistance layer, step-selection functions and path-selection functions provide the most powerful selection function for deriving resistance surfaces, because they reflect observed movement pathways (Zeller et al. 2012). In all cases where an RSF is used as a resistance surface, validation of the layer with an independent empirical dataset of species movement is required to confirm that the RSF-based resistance layer is providing an accurate representation of animal movement (Cushman et al. 2013, McClure et al. 2016).

RSFs essentially constrain a connectivity analysis to a species-specific analysis. Determining landscape connectivity requires that a wide range of species be modelled and requires an RSF for each focal species (e.g., WWHCWG 2012), which can be cost- and time-prohibitive. However, connectivity analyses have advanced such that there are now numerous methods and software for assessing connectivity and delineating corridors (e.g., Theobald et al. 2006; Compton et al. 2007; Majka et al. 2007; McRae et al. 2008; Cushman et al. 2009; Saura and Torne 2009; Landguth et al. 2012; Bras et al. 2013; Carroll 2013; Pelletier et al. 2014), some of which can be adapted to be non-species-specific methods, relaxing the requirements of cost-prohibitive field data (or occurrence RSF data), or the limitations associated with an umbrella species or single indicator-species approaches. Notable examples of connectivity analysis include those applying least cost approaches (WWHCWG 2010, Cushman and Langduth 2012, Cushman et al. 2013, 2013b) or circuit theory approaches (McRae et al. 2012, Dickson et al. 2013, Koen et al. 2014, Pelletier et al. 2014, Ayram et al. 2016).

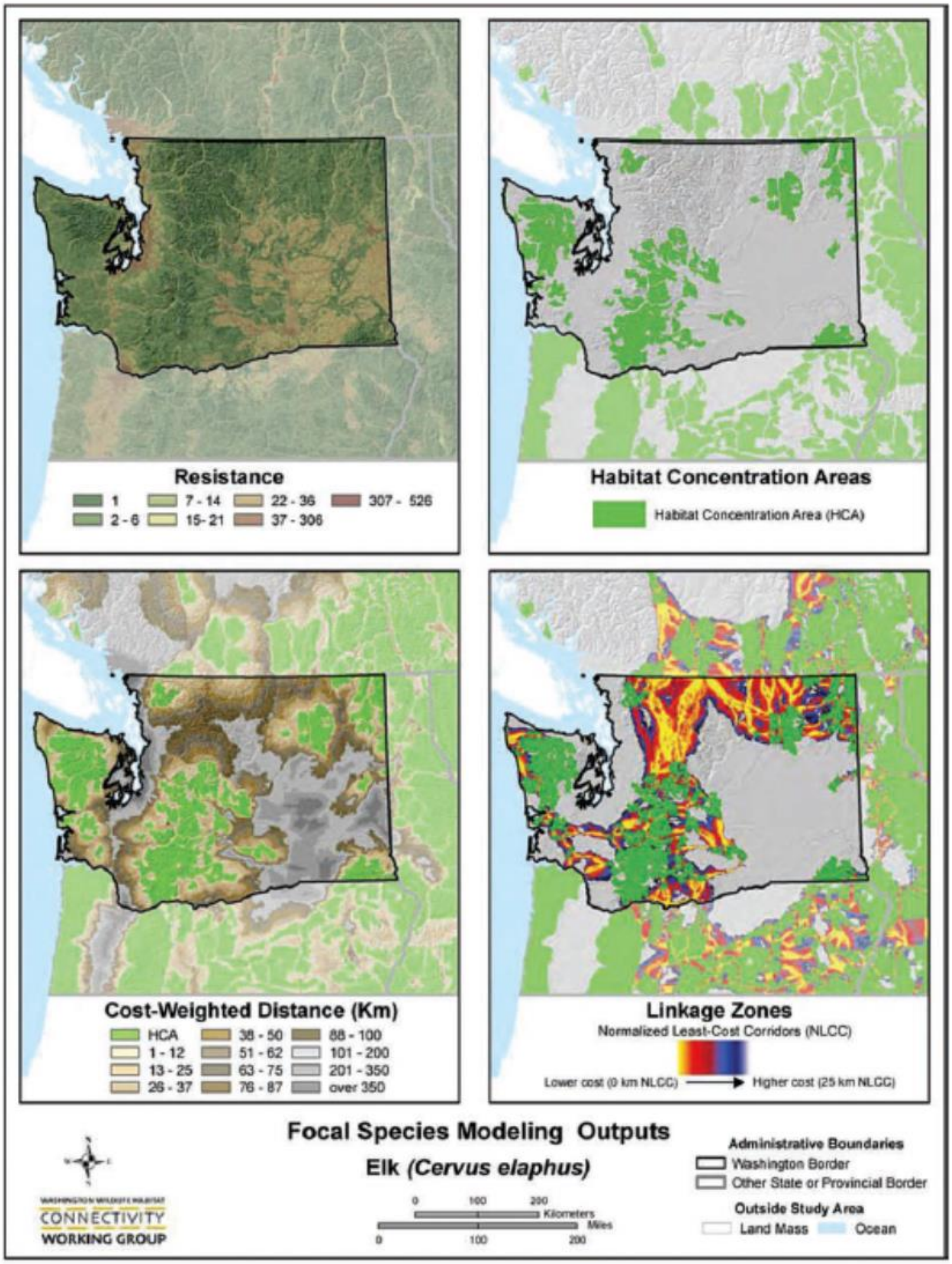


Figure 1. Connectivity modelling of elk performed by WHCWG (2010). A resistance layer based on biological knowledge of elk (top left) is combined with locations of core habitat determined from a species occurrence model (top right) to determine the cost of movement between core habitat (bottom left) and then map the location of important linkage zones or corridors (bottom right). This example is large-scale, but the same methods can be applied at very local scales; like just to the Canmore area, or even just the Resort Center.

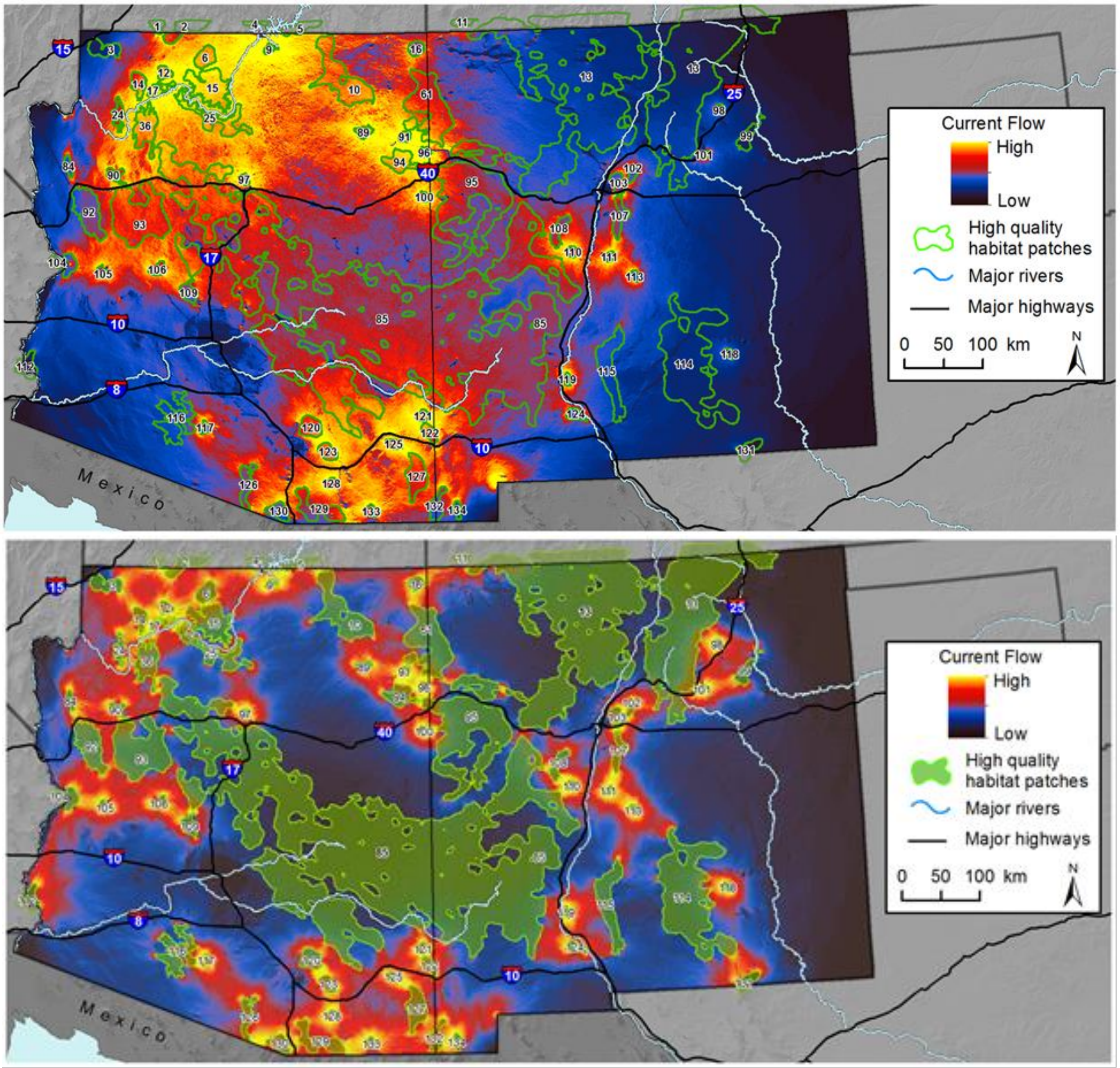


Figure 2. Connectivity analysis of pumas using circuit theory to calculate cumulative current flow (top), which identifies areas important for keeping the network of core habitat connected, and areas of maximum current flow, which identifies locations of possible “pinch points” (bright yellow locations) between high quality habitat patches which are overlaid (below) (from Dickson et al 2013).

Connectivity and the Resort Centre EIS

Through our review comments, we were not effective in having wildlife movement and habitat connectivity considered in the Resort Center EIS, even despite the current scientific consensus that connectivity modelling is the most appropriate method for assessing baseline wildlife-movement conditions. While the scope of the EIS does not include the location and width of the designated corridors as these are the responsibility of the Province, the fact remains that the proposed development will both directly and indirectly effect lands within the wildlife corridor, and in turn, these effects will likely influence the way that wildlife move through and utilize habitats within the wildlife corridor. The lack of a connectivity analysis leaves a notable gap in our understanding of the wildlife corridor's baseline conditions, and by extension, the potential impacts that this development may pose to wildlife.

Notably, the EIS suggests that the TOR outlined a specific requirement for an analysis of "*animal behaviour and selection of habitats already designated for protection as movement corridors by the Province*" (EIS, Page 46). However, we note that there was no such requirement set forth in the Terms of Reference for this EIS. Further, as we have stated above, for many species of wildlife moving and navigating through an area is ecologically different than selecting for resources within an area. Despite this ecological reality, the EIS states that RSF outputs can be interpreted as a resistance layer similar to those employed in a connectivity analysis:

> *"… increases in probability of selection can also be interpreted as reducing resistance and increasing the likelihood of movement through a given area on the landscape* (EIS, Page 45)*."*

While RSF outputs are commonly used as inputs into the creation of resistance surfaces as one component of connectivity modeling, assuming that there is an inverse relationship between resource selection and wildlife movement (i.e., highly selected areas offer low resistance to movement) is an oversimplification of how animals move through the landscape. While habitat quality is a factor in how and where an animal moves, there are myriad other factors that drive movement, and these are not captured well within RSF models. In fact, there are many instances, particularly with territorial animals, where movement through high-quality habitat is more difficult (e.g., because of competitive interactions with conspecifics) and it becomes easier to move through low-quality habitat instead. Of course, it can be challenging to parse out environmental conditions associated with local resource use from those conferring resistance to movement; however, this is not impossible, and because this development is adjacent to a wildlife movement corridor we argue this must be, and remains to be, addressed as part of the impact assessment. Further, the fact that telemetry data exist that could be used both to develop and validate a connectivity model would greatly enhance the reliability of the model, as compared to one that was created using best professional judgement alone.

Interestingly, in support of using their RSF output as some form of a connectivity layer, the EIS cites Abrahms et al. (2016);

> *…whereas the highest quality habitat facilitates movement (i.e., low resistance) (Chetkiewicz and Boyce 2009; Abrahms et al. 2016). Therefore, increases in probability of selection can also be interpreted as reducing resistance and increasing the likelihood of movement through a given area on the landscape. (EIS, Page 45)*

However, a closer look at Abrahms et al. (2016) reveals the inverse, in that RSF models likely misrepresent habitat connectivity or predicted movement on a landscape;

"Our review indicates that most connectivity studies conflate resource selection with connectivity requirements, which may result in misleading estimates of landscape resistance, and lack validation of proposed connectivity models with movement data. Our case study shows that including only directed movement behaviour when measuring resource selection reveals markedly different, and more accurate, connectivity estimates than a model measuring resource selection independent of behavioural state. Resource selection analyses that fail to consider an animal's behavioural state may be insufficient in targeting movement pathways and corridors for protection. This failure may result in misidentification of wildlife corridors and misallocation of limited conservation resources."

It must be clarified here that the Resort Center EIS did not differentiate telemetry data based on behavioural state, most likely because only relatively few animals were used in the modelling, and there would have been insufficient data had they only used movement. Thus, we maintain that a connectivity analysis, using a scientifically credible approach, is required to better understand the potential impacts of this proposed development on wildlife resources. Without such an assessment, the uncertainty related to how this development will impact wildlife species of conservation concern remains high.

Connectivity models can be developed at large or local scales. The examples provided above (i.e. Figure 1 and Figure 2) are relatively large in scale; however, the same methods can be applied at scales more relevant to the Resort Center. A good example of this at a municipal-planning scale is the connectivity model that has been developed for the City of Calgary (Fiera Biological 2016), which can be used to assess development planning at either city-wide or local-neighborhood scales (e.g., Figure 3 herein). In this example, a resistance layer was developed using urban land-cover features and Circuitscape modeling was completed to determine city-wide landscape connectivity, with output equally informative at the local neighborhood scale. A similar approach would be particularly informative for the Town of Canmore and its surrounding landscape.

Although in the following sections we address the specifics of the RSF modeling completed in the EIS, we must clarify that an RSF approach alone within the context of the Resort Centre proposal is ecologically and scientifically incomplete; it only represents one component of a more complete analysis of existing wildlife movement conditions. But if anyone did choose to accept the use of RSF models in the Resort Centre EIS, we caution the validity of their output, namely because of discrepancies in land-cover classifications, and in missing information making the RSF output difficult to interpret. We describe these concerns in more detail below.

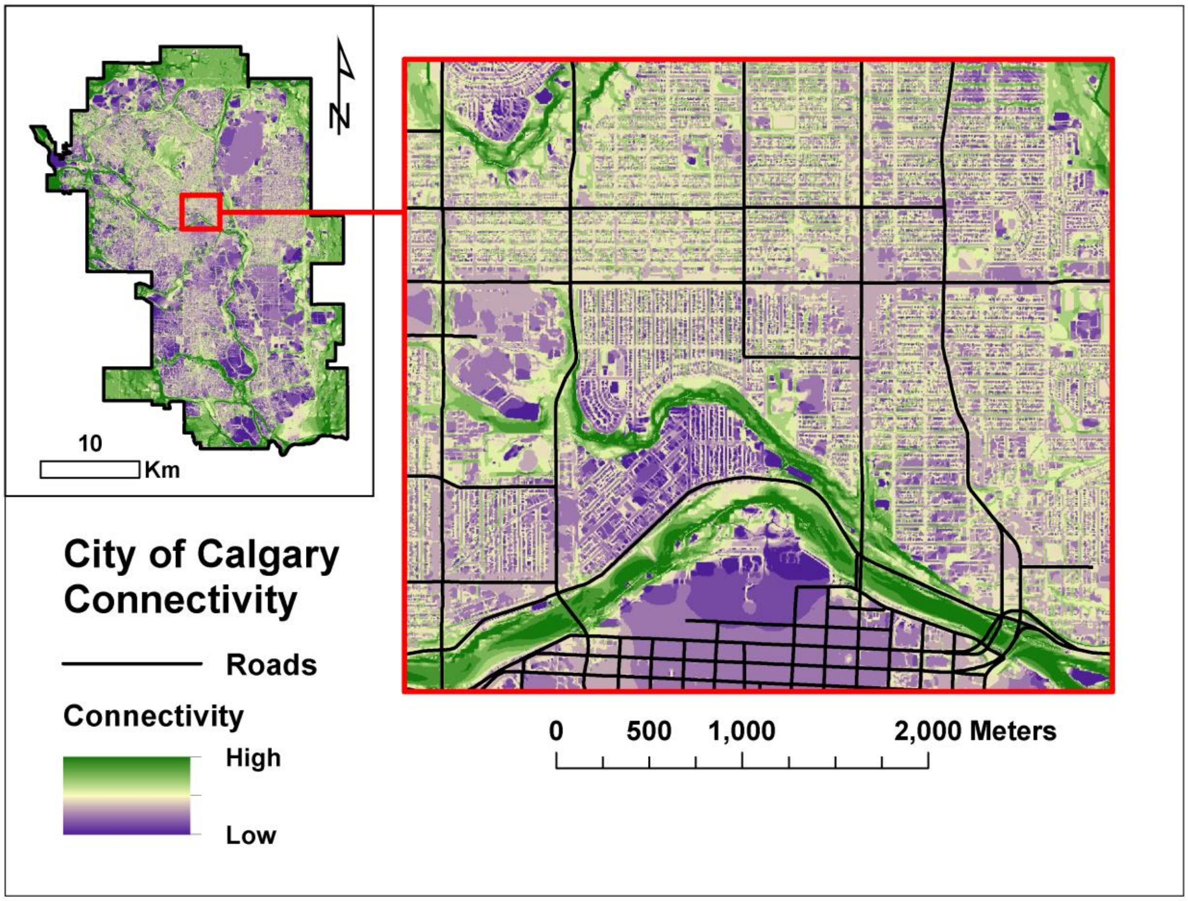


Figure 3. A municipal-scale example of a connectivity model developed for the City of Calgary (Fiera Biological 2016) showing both city-wide and neighborhood-scale examples of how the model output could be used to assess developments across scales. That is, a connectivity approach can be used to assess the entire Bow Valley, or could be focused just on the Resort Center area.

2.2. Methodological Issues in the Resort Centre RSF Modeling

Land Cover Data and Habitat Modeling

Age of Wildlife Telemetry Data versus Age of Habitat Data

Land cover data are foundational to all habitat modelling exercises. If land cover input layers do not accurately reflect the landscape upon which ecological processes are being modelled, then the accuracy of the results will decrease and the uncertainty associated with model predictions will increase. Accurate and up-to-date land cover data are particularly important in landscapes that are dynamic and change as a result of natural events (e.g., flooding, forest fire) or due to anthropogenic changes. For example, between 1999 and 2013, the Town of Canmore has undergone substantial changes in land cover that has influenced the amount, type, and distribution of natural cover present, with increasing human footprint both within and outside the municipal boundaries.

Animal-habitat selection is influenced by the land cover type and the intensity and nature of human use within land cover types. Therefore, it is important to use animal-telemetry data and land cover data that are contemporaneous. That is to say, animal locations from telemetry data and the associated land cover map should be collected and created at the same time. This is critical for habitat modelling, because RSF models are mathematical predictions of habitat preference that are created based upon the relationship between a known animal location and the associated habitat in which that location was collected. Thus, we cannot collect animal data in (for example) 1988 and then relate these locations to a land cover map from 2009, because it is very likely that the animals in 1988 were not experiencing the same landscape that exists in 2009.

However, animal data are almost always collected over multiple years, particularly for larger species like the ones examined in the EIS (i.e., wolves, elk, bears, and cougar), and so it quickly became best practice for wildlife researchers to create yearly updated land-cover layers so that animal data collected in 1988 was analysed using land cover from circa 1988. For example, if telemetry data from years spanning 2000 to 2004 are being used to create a habitat model, it would be most appropriate to create a land cover layer for the years 2000, 2001, 2002, 2003, and 2004, and to overlay the telemetry data from the corresponding year to extract habitat values. This approach ensures that any animal response to changes in land cover are reflected in the data used for modeling.

The Resort Centre EIS has evident discrepancies between the dates animal data were collected versus the dates land covers were potentially created. The EIS methods report using the animal telemetry data over a number of different years for construction of RSF models (Appendix B, page 3/38, Section 2.1.3.1):

- Grizzly bear data came from five individuals (three males and two females) collared during 2000-2008;
- A total of 797 wolf use locations were obtained during winter from 22 VHF collared wolves during 1988-2003;
- Elk locations were obtained during winter from 11 animals collared with VHF collars during 2000-2003 (189 locations) and 4 GPS collared animals wearing Telonics (Messa, Arizona) collars during 2009;
- Cougar location data were derived from 5 individuals collared with Televilt-Simplex GPS radiocollars (Lindesberg, Sweden) programmed to obtain a fix either every 1 or 4 hours during 2000-2004.

In some cases, the telemetry data spans a relatively small number of years (e.g., cougar), while in other cases, such as for wolf, the telemetry data spans a period of 15 years. The EIS acknowledges this temporal dynamic and the importance of tying animal locations to accurate land cover data (Appendix B, page 12/38, Section 2.1.3.3):

> *Because wildlife telemetry data were obtained over long periods of time (i.e., 1988-2009, depending on species) it was important to account for landscape changes caused by human development during that period.*

However, the methods are unclear on how the temporal changes in land cover were measured and accounted for in the development of the models. The only explanation for dealing with changes in land cover through time was (Appendix B, page 12/38, Section 2.1.3.3):

> *Wildlife location data were therefore applied integrated with land cover layers depicting development prior to and after 2004, depending on the date associated with the telemetry location.*

From this description, it is not clear whether a land cover layer was created for each year that telemetry data were available, or whether a "representative" year was selected prior to 2004, and after 2004, and these land cover layers were used to extract habitat information from the animal telemetry data. If it is the case that only two time steps were used (e.g., a pre-2004 and a post-2004) to create the land cover data, it is not clear from the methods *which* years prior to 2004, and after 2004, were used in the modeling.

From the description provided in the methods, we have assumed here that two time steps were selected – one prior to 2004 and one after 2004 – and these years were used to create land cover maps that were then used to extract habitat information to build the RSF model predictions. If this is the case, then we caution that this approach may have introduced error into the models that could potentially be significant. This concern is noted in the EIS methods; however, they argue that they could not address the issue because of a lack of data, and simultaneously, offer that the effect is expected to be "minimal" (Appendix B, page 12/38, Section 2.1.3.3):

> *Data were unavailable to make finer temporal divisions. This may not account well for wolf data collected in the late 1980s and early 1990s, but because most wolf locations occur west of Canmore where new development over the last two decades has been less pronounced, the introduced bias was expected to be minimal.*

As for data availability to address this, we offer that there are several different data sources that could have been used to create annual land cover maps. These include freely available Landsat data with a monthly archive of images going back to the 1970s, as well as annually flown air photos that could be obtained from the provincial air photo library, or from the Town of Canmore directly. In fact, the Town of Canmore has made a number of air photos from 2003, 2008, 2009, and 2013 freely available through the Calgary Region Open Data Partnership (http://www.calgaryregionopendata.ca/browse?q=canmore). This website also has other data that would be useful in creating updated land cover layers, such roads, building footprints, and land use zoning.

To illustrate the importance of using appropriate land cover data to create habitat selection models, we provide an example of how the landscape within and near the Resort Centre boundary has changed between 1999 and 2013 (Figure 4 herein). In this example, we highlight locations where the land cover class assigned to a particular location would change between the two time steps (e.g., a change from "forest" to "developed"), and we question exactly what proportions of the "change" areas (noted as pink areas in Figure 4 herein) were included in the "post-2004" land cover versus the pre-2004 land cover. We suggest that these discrepancies could substantially influence habitat selection preferences, and would influence the used and available locations that form the basis for the RSF models. Thus, it becomes very important to understand how the land cover data that were used in the Resort Centre EIS were updated and then related to animal telemetry data over time. Exactly what vintage of land cover that was used remains unclear.

Further, there are other cumulative effects unrelated to footprint that could have been driving animal telemetry locations, and this is why there must be close alignment between wildlife data and land-cover data. For example, the areas west of Canmore arguably have seen large increases in human recreation that would undoubtedly displace or otherwise affect wildlife locations, even though newly cleared areas remain relatively low there. Or, the known development surrounding Canmore may have altered competition or territory locations as populations are potentially forced east from development. These are hypothetical examples, of course, but illustrate why tying animal locations to up-to-date habitat information is important for the creation of reliable models. Without more clarity related to what years were used to create land cover maps, and how the land cover data were related to the multi-year telemetry data, it is difficult to properly evaluate the reliability of the RSF models presented in the EIS.

Accelerated Restoration versus Land Cover Reclassification

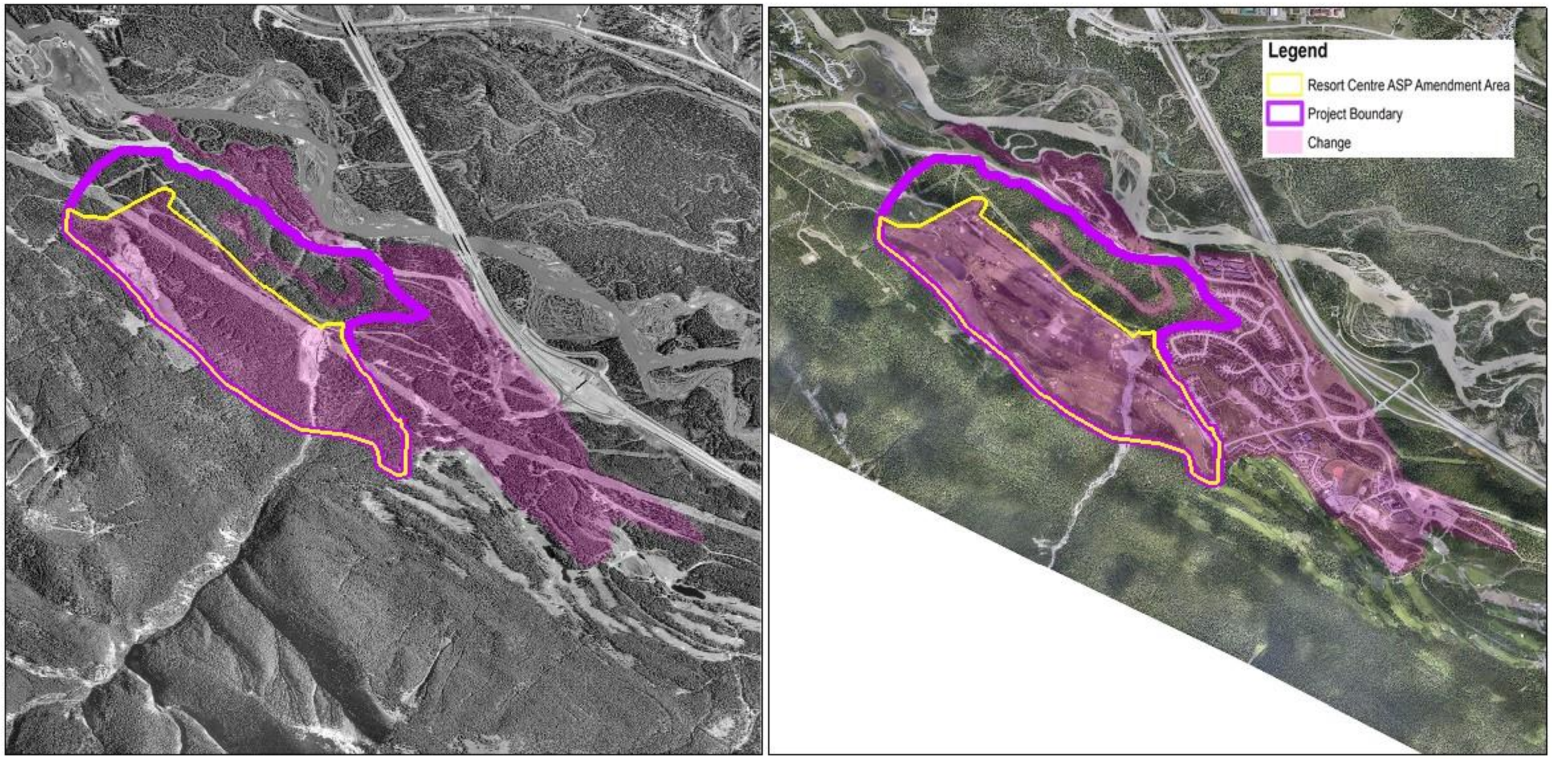
More specific to the Resort Centre lands, we also note a discrepancy in how the golf course lands were defined or classified in their “current state”, versus how the same lands were apparently reclassified in the land cover data that were used as an input into the RSF models. In particular, we noted that the model output for this analysis in 2013 indicates that the unfinished golf course lands were considered human-use areas avoided by grizzly bears, yet three years hence these same lands are the inverse and are now high-quality grizzly bear habitat (i.e., Figure 5 herein). From this it appears that the land cover data have been updated without detailed rationale for why this has occurred. Further, the EIS provides contradictory descriptions of the vegetation cover on the golf course lands, which makes us question the validity of the land cover data used for the RSF modelling.

The EIS describes the unfinished golf course lands as:

> *Non-native grasslands are the most common cover type in the Resort Centre ASP Amendment area (i.e., 44.3%) and are associated primarily with the unfinished golf course. These areas were seeded with non-native grass, although some native species also are present, and weeds have invaded some areas.* (EIS, Page 146)
>
> *In addition, because the unfinished golf course on the Resort Centre is not managed or used like other golf courses in Canmore, the designation was changed from one of “golf course greens, tees, and fairways” (Golder 2012) to “herbaceous grassland” for application of the models to all analyses undertaken for the Resort Centre ASP amendment and Smith Creek ASP. This change was made to more accurately reflect the ecological conditions and types of human use that occur on the abandoned golf course.* (Appendix B, Page 1/38)

And upon requesting further clarity on this we were informed by the authors;

> *In the 2013 EIS, the grizzly bear model runs did not treat the abandoned golf course as anthropogenic grassland, even though by that time it had developed vegetation characteristics that were likely to be selected by grizzly bears.* (Email communication from Golder and Associates, March 23, 2017)



1999 **2013**

Figure 4. Comparison of the land cover within and near the Resort Centre in 1999 and 2013, highlighting areas where the land cover class potentially changed markedly between the two unreported time steps, illustrating the importance of tying animal telemetry locations to land cover data that is representative of the landscape at the time the animal location was obtained.

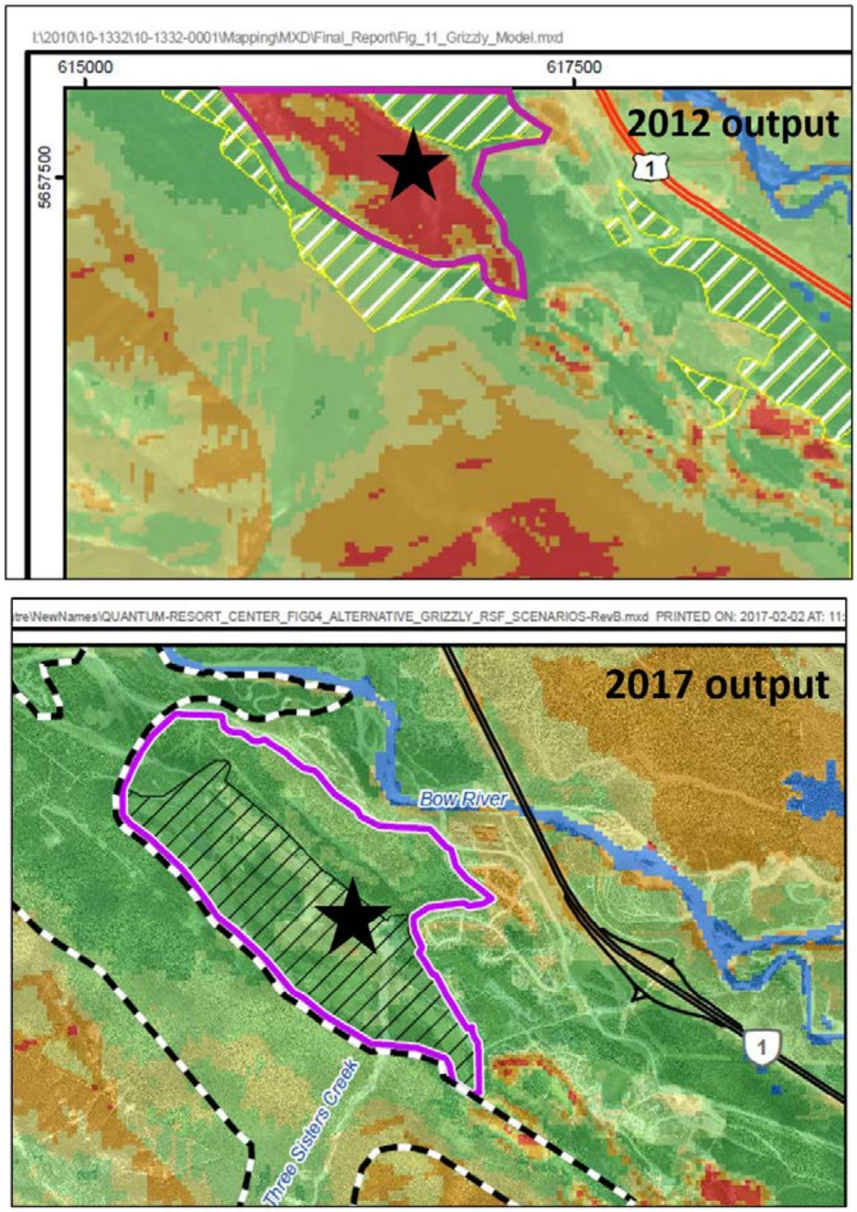


Figure 5. Comparison of RSF output from the same models run in Golder (2012) versus here in 2017. The black stars indicate the same spatial location within the purple boundary of the Resort Centre ASP. Both are purported to be "existing case" yet they are the inverse of each other.

We are thus left with a somewhat confusing chronology of exactly how the most important land cover areas in this EIS were classified, let alone how other land cover types were classified for this analysis. In 2012/2013, the golf course lands appear to have been considered human-impacted areas that are highly avoided by grizzly bears, yet within three years hence these same areas are highly selected by grizzly bears.

To evaluate this further, we acquired the 2013 color air photo for the Resort Centre ASP area (Figure 6 herein) and even from a cursory inspection we cannot understand how this area in the relatively high-elevation slow-growing montane and sub-alpine region, could possibly regenerate sufficiently such that within three years it changed even qualitatively from highly avoided to highly selected habitat. That is, the mechanism driving this EIS's habitat-quality output is not an ecological one, rather it is simply a land cover classification artefact that, in our opinion, is questionable and implicates the validity of the land cover data used for the RSF modelling. We only noted this issue in land-cover classification choice because it happened to coincide with the Centre of the ASP lands and had associated and contrasting RSF output to serve as an indicator of potential inconsistencies; otherwise it would be almost impossible to identify. And so based on this we caution that there are possibly other land-cover classification issues that potentially implicate the results of this EIS, but that cannot be evaluated directly because there is no land cover map provided in the EIS for evaluation. Given this lack of transparency in land cover data, we caution any interpretation from these data.

Without more clarity on land cover data, it becomes very difficult to interpret any of the model output in this EIS, and particularly so where there are possible discrepancies. We found this for the scenario modeling. For Scenario 1 shown in Figure 3 of the EIS, we noted an abrupt change in habitat quality from red to green along the southern boundary of the Resort Centre polygon, which we cannot rationalize given the methods that were provided in the EIS, and the discrepancies noted above. The southern boundary of the ASP is somewhat unremarkable, so we are not clear why the RSF would predict such a marked edge from red to green with no intermediate transitions (yellow or orange) in between, as is seen in Scenarios 2 and 3, particularly since many of the variables driving the model were associated with 150 m+ sampling scales, suggesting that abrupt change would be unlikely because, as noted in the EIS methods (Appendix B) larger scales will smooth RFS probabilities because adjacent cells necessarily have similar properties. Transition zones between colors should exist. Normally we would evaluate the top-ranked model and associated selection coefficients to determine what might be driving this change, but we found discrepancies and inconsistencies in the other aspects of the modeling results that prevented us from further interpretation. We describe these in more detail below.

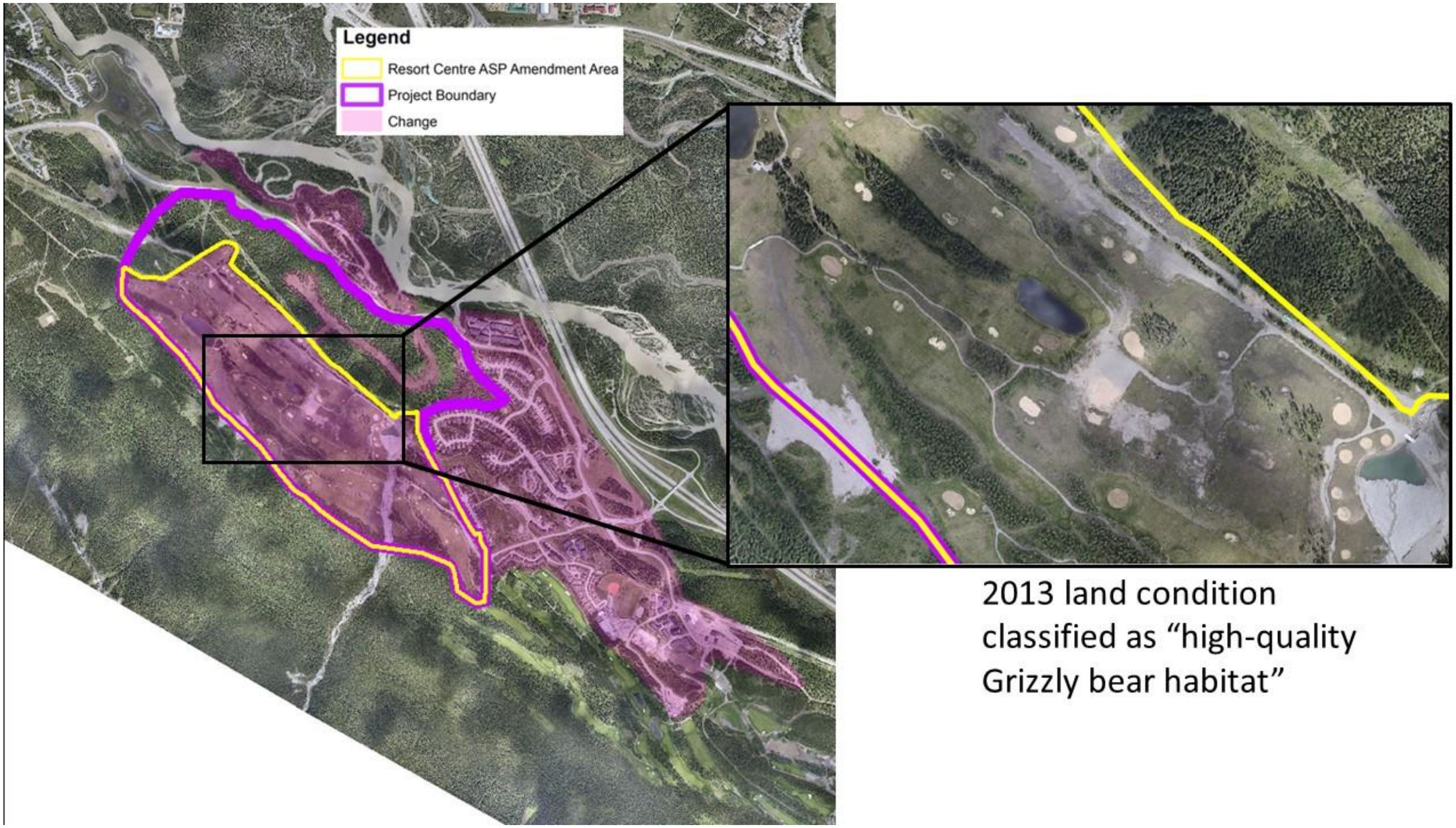


Figure 6. Condition of the Resort Centre lands in 2013 illustrating why the reclassification from "golf course" to "high-quality herbaceous grizzly bear habitat" is questionable, and how this may implicate the validity of the land-cover used in the EIS. The magnified portion in this figure is not indicative of high-quality herbaceous habitat.

Missing Components of the EIS's RSF-Model Selection

There are four main steps in developing and choosing a mathematical model representing the relationship between an animal's space use and the structured environment. We briefly summarize these below to contextualize the methods used in this EIS and some of the discrepancies we found with these.

First, a series of hypotheses must be generated that suggest possible mechanisms linking animal presence to habitat structure. For example, one hypothesis might be "grizzly bears use trails where buffalo berries grow because this provides both efficient travel routes and high-quality food sources." In wildlife studies, often there will be upwards of 20 different hypotheses like this.

Second, a proposed mathematical relationship is created to correspond to each hypothesis and using habitat variables that are measured either in the field or in a GIS environment. These are called the "candidate models" to be tested against the data. For the above hypothesis, one might say its candidate models is [bear habitat use = (%berries) + (trail length) + (elevation)] because our hypothesis suggests berries on trails are important, and perhaps these are also a function of elevation because berries are more abundant at lower elevations.

Third, all of the mathematical relationships are entered into statistical software and evaluated in a relative context to compare which hypotheses and corresponding mathematical equations are best supported given the empirical data, which in this case, includes telemetry data from animals that had GPS collars.

And forth, the top-ranked models that best fit the data are identified and then their corresponding hypotheses are interpreted and scrutinized ecologically by discussing the model output within the contexts of the biology of the animal being modeled. All of these steps are required, otherwise model transparency is low and the scientific validity of the process cannot be evaluated.

The wildlife modeling in the Resort Centre EIS lacks two of these four required components; namely, there are no hypotheses to support the models and no ecological interpretations of the best-ranked models.

Models arise from careful questions about biology and the manner in which biological systems function. Development of a set of candidate models is based upon potentially relevant effects and causal mechanisms thought likely, based on the science of the situation, to affect animal location. This set of candidate models represent plausible alternatives based on what is known or hypothesized about the process under study. To properly evaluate candidate models, each combination of landscape variables hypothesized to affect an animal's probability of selection needs to be described with a verbal narrative that translates the hypothesized mathematical relationship into a verbal statement on animal ecology, and therefore it is generally recommended that a considerable amount of careful, advanced thought be invested in arriving at a set of candidate models. However, a clear explanation of why each individual candidate RSF model was chosen is not provided in this EIS, and therefore the RSF output cannot be fully evaluated.

Although the EIS provides a general literature review outlining different aspects of animal selection for bears, wolves, elk, and cougar, it does not tie these together into hypotheses explaining why each candidate model was chosen to be evaluated in this analysis. That is, we are left to interpret;

> *"greenness elev elev2 builtup_300 elevnonveg_600 south_slope_600 dens_trails_600 forest_edge_600 herb_600 golf_150 shrub_600 dens_roads_600 dist_builtup"*

And we are expected to interpret this ourselves. This combination of land-cover variables could mean any number of things, even to an experienced statistician. There appears no clarity on the mathematical relationships of the variables effectively separating possible interaction effects from individual variables from quadratic functions. For instance, we interpreted “elev elev2” as an interaction of a variable with the square of itself, or possibly as an interaction with the variables “greenness” or “builtup_300”, when in fact this could also be intended as a quadratic function using the square of elevation (but the correct form would be “(elev + elev2)” which is not presented). So, even the mathematical interpretation of the RSF models requires guesswork. For a complete assessment of the RSF approach in this EIS, one requires a specific hypothesis corresponding to this exact combination of variables, not just a general literature review about bear-habitat selection lists of variables using their raw-data spreadsheet titles, with the mathematical relationships amongst each left equally vague. Without this contextualization, we cannot evaluate the relative appropriateness of the models chosen for analysis.

Transparency in how mathematical models are created is paramount to assessing scientific validity, and in this case, we are left questioning both the hypotheses used to create candidate models, and the basic mathematical intent involved with each model.

Beyond the modeling specifics, we also found gaps in the scenario modeling that the RSF output was used in examining potential effects of human use on habitat selection.

2.3. Incomplete Assessment of Human Use in the Wildlife Corridor

Scenario Modeling Varied From Actual Development Intent

We applaud the use of scenario modeling, the potentially fundamental issues with the RSF model output discussed above notwithstanding. We argue this is an important requirement to understand potential effects of the Resort Centre development on existing conditions, particularly given its spatial proximity to wildlife corridors. As well, scenario planning in the context of assessing environmental impacts is appropriate given that there is a significant amount of uncertainty regarding the number of units that may be built on the Resort Centre lands, and the associated population related to those units. For example, the previously approved ASP allowed for the development of between 1339 and 2525 units, with a corresponding population of visitors and residents ranging between 3,192 and 6,060 (Golder 2017). The Resort Centre ASP amendment proposes an increase in the number of units to a minimum of 1,600 and a maximum of 3000, with a potential population ranging between 4,000 to 8,000. This range in the number of units, the built form of those units (e.g., high density versus detached single family), the spatial arrangement of the units (e.g., clustered versus dispersed), and the wide range of population associated with different neighbourhood development scenarios all have potentially different direct and indirect impacts on wildlife and environmental resources. These various combinations were not examined with reference to existing conditions.

Further, we would expect that the potential increase in human use of the adjacent wildlife corridor would be directly linked to population: the larger the population, the more likely that you will have an increase in the use of the corridor by residents and visitors. Thus, it is conceivable that there is a unit density, associated population range, and a spatial development configuration that results in a “minimal impact” scenario, and this scenario would be preferred over other, higher impact scenarios. We illustrate this in Table 1, where we have provided a range of hypothetical scenarios that could have formed the basis for scenario planning for the Resort Centre EIS. Importantly, we consider this scenario analysis an important component of project mitigation, as selecting a development concept that minimizes both direct and indirect impacts would be considered an appropriate mitigation approach.

The Resort Centre EIS did include scenario modelling, which examined three potential development scenarios; however, this scenario modelling was limited to assessing impacts only on habitat quality directly associated with building footprints, and did not consider different unit or population densities and the associated range of increase in human use of the corridor that would result. An important component of this analysis was that with each change in development scenario, there would be an associated change in both sensory disturbance and human-based recreation expected adjacent to the ASP area that would affect the corridor's baseline conditions; however, this range of scenarios was not examined as part of the EIS.

Recognising that planning details at the ASP stage tend to be non-specific, we suggested that the EIS present a number of potential development scenarios that were realistic and reflective of future land development in the Resort Centre EIS footprint (Table 1). This approach would provide a better understanding of the potential impacts of each of the scenarios on baseline conditions, with particular focus being on how these scenarios would directly and indirectly impact habitat use and movement of key wildlife of concern (e.g., grizzly bear, wolf, cougar, elk). Further, these scenarios could then be used to *inform* more detailed planning, as the scenario that presented the lowest risk to the VECs of greatest concern could be used as the basis for more detailed neighbourhood planning.

We feel strongly that scenario-based assessment of development alternatives is required, particularly for a proposed land development amendment that is situated adjacent to provincially designated wildlife corridors in one of the most important valleys for the movement of large carnivores in Alberta. In order for this approach to be informative, it would have required that each scenario be evaluated in the context of the predicted direct and indirect impacts of the project on habitat use and movement of wildlife species of concern.

Throughout this EIS-review process we have continuously raised concerns over the increase in the number of people that would be associated with the development, and implications of this increase on the number of people who may enter the wildlife corridor for recreational pursuits. This is arguably the most critical impact on wildlife that may result from this project, an impact that has also been acknowledged within the EIS:

> *Human use within wildlife corridors also has the potential to affect wildlife use of the corridor, but the amount of human use in the corridor is expected to be driven more by the number of people in the development, and less as a function of different footprint designs. (EIS, Page 13)*

However, the EIS goes on to note that:

> *Because the number of people associated with new development within TSMV is a function of the number of units granted under DC 1-98, the analysis did not evaluate the potential effects of variation in the number of people associated with the development on wildlife corridors or the amount of negative human-wildlife interactions, but instead evaluated the spatial configuration and density of different conceptual footprint options* (EIS, Page 13-14).

As such, the scenario analysis examines changes to the predicted level of habitat selection within the development footprint and adjacent wildlife corridor *in absence of any effect of increased human use in the corridor*. As a result, they make conclusions and assertions such as:

In summary, the effects of the three development scenarios changed the predicted extent of selected and used as available habitat for grizzly bears within the Resort Centre ASP, but the development scenarios did not change habitat selection patterns in the adjacent Along Valley Corridor (EIS, Page 19)

These conclusions are not well supported analytically. We argue that a range of values in human use, from low to high, should be explored to understand the potential impact that an increase in human-use might have on habitat selection and wildlife movement. Thus the EIS remains deficient in achieving the alternative analyses outlined in the EIS TOR.

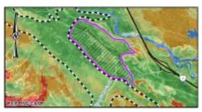
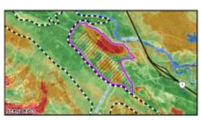
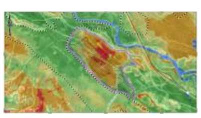
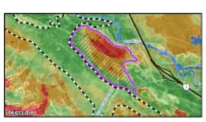
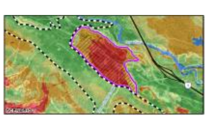
Moreover, for the instances where human use is addressed, it is integrated using what appear to be static disturbance coefficients that were selected using best professional judgement (BPJ). While best professional judgement is often used in absence of empirical data, we note that there are somewhat extensive human-use data available for the area of interest, and to our knowledge, these data were not used to inform the selection of the disturbance coefficient, or to generate a realistic range of possible disturbances based on actual human-use data. Further, when BPJ is used to select variables for modeling, it is good practice to select a range of values rather than a single value, to examine the phenomenon of interest, as it is generally acknowledged that values selected using BPJ can be less accurate than values selected using empirical data.

The rationale behind the selection of disturbance coefficients is important because we suspect that a primary concern for many regarding this development is not only what will be affected post-development, but how close this area's existing conditions might be to an ecological threshold that would result in negative effects. That is, given the human-use data available for the area, are there thresholds that are already being exceeded given existing development permissions, let alone those under review? This issue remains to be addressed, and we argue that this is an important cumulative effect that should be examined in the context of this ASP amendment.

While we approve the use of disturbance coefficients and acknowledge the biological references to flight-initiation distances (FID) in the application of disturbance coefficients in the revised EIS, we are concerned with their selective application in the EIS. We have three main concerns with their selective application that fundamentally implicate the validity of the human-disturbance results presented in the EIS.

First, disturbance coefficients have only been applied to primary trails and not to undesignated trails that human-use data clearly indicate are already being used. The rationale for exclusively limiting disturbance to primary trails while excluding any proximity to development is unclear. We agree with a disturbance coefficient being applied to trails, but we would argue this coefficient is equally applicable to all trails present in the wildlife corridor. Placing a 5% reduction only to primary trails and not undesignated trails implies that the effectiveness in mitigating the use of non-designated trails will be 100% even with a concurrent doubling of human population in the adjacent development. We question this assumption, and this again reflects the apparent disconnect between mitigation and monitoring, because if mitigation is already being anticipated as 100% effective, then neither monitoring nor adaptive management are required. However, there is no evidence to suggest that any of the mitigation strategies will be 100% effective in reducing or limiting human use of the wildlife corridor, and this extends perhaps most prominently to the proposed exclusion fence addressed in Section 3 below.

Table 1. Using hypothetical numbers within the ranges of the existing and proposed unit densities for the Resort Center ASP, this table outlines different potential scenarios and their associated direct and indirect effects and how these could be evaluated for an adaptive management framework. Inherent in this approach is the ability to manipulate both land-use footprint and the associated unit densities within each, such that the effects of where things are built can be explored alongside of the associated population densities expected for each build out. The different footprint scenarios below are meant to represent alternatives for the physical placement of different unit densities, either by placing them closer together versus expanding them out into the unfinished golf course. Examining footprint options alone can address both direct habitat loss from the development footprint and indirect effects (e.g., light, noise, etc.) that might extend into the adjacent corridor. And for each footprint scenario, there is also an associated range of expected human use affecting the adjacent corridor. These human-use effects can also be explored (i.e., adjusted) in reference to expected mitigation effectiveness; namely education and enforcement. Scenarios are hypothetical and could include different or additional combinations.

Footprint-pattern Scenario (direct habitat loss)	**Number of Approved Units**	**Expected Indirect Disturbance from Footprint**	**Expected Population Density**	**Expected Increase in Human-Use in Corridor**
 Existing state compact- min units	1339	+7%	3000	+10%
 Existing state compact- max units	2525	+7%	5500	+20%
 Scenario 1 new footprint – min units	1600	+12%	3500	+15%
 Scenario 2 new footprint – more units	2000	+14%	4100	+18%
 Scenario 3 new footprint- max units	3000	+14%	7000	+30%
 Scenario 4 max footprint – max units	3000	+20%	7000	+30%

Second, disturbance coefficients are not applied to the development footprint itself, even though human use would *de facto* come from adjacent development. In fact, an examination of the EIS's Figures 19 and 20 clearly demonstrates that human use and neighborhood development were examined independently even though they are inextricably linked. The EIS approaches human use in isolation of associated indirect effects like noise, light, and odours which, in accumulation with human recreation, all add simultaneously to cumulative effects, the mitigation of which was supposed to be a primary objective of the EIS. Why human-based disturbance would only extend in distance from primary trails and not simultaneously from other human-footprint features indicates that much further work is required to properly address even local-level cumulative effects.

And third, we are equally unclear why a doubling in human population density only results in a 5% RSF reduction via the disturbance coefficient. For example, in Appendix B, Table B-14, for grizzly bears, if a designated trail is within a habitat patch, the patch's quality is reduced 15%; then as the human population is simulated to *double*, this quality is only reduced an additional 5%. But it is unclear how a full development (the previous paragraph above notwithstanding) and doubling of adjacent human density can only result in a 5% reduction of habitat quality. Given the FID narrative provided in Section 3 of Appendix B, we would have expected some more transparent explanation linking development with human use and the FID of various wildlife species (e.g., Figure 7 herein).

We question whether this 5% reduction is too low, particularly when we compare the two grizzly bear output figures that show RSF values before and after the human-use disturbance coefficients are applied (EIS Figures 19 and 20): they are literally identical within the Resort Center project boundary, and almost identical outside (see Figure 8 herein). This raises questions over how the five RSF "probability of selection" categories indicated in the EIS's Figures 19 and 20 were parsed out from zero to one. If these were equally partitioned, then each category would contain 0.2 or 20%, and a 15% reduction would be more evident. Instead, EIS Figures 19 and 20 are almost identical; thus, an understanding of how RSF categories are partitioned is an important and missing component of the methods employed. Also, if selection categories are equally partitioned, then a 5% disturbance coefficient arguably could be hypothesized *a priori* to be irrelevant in demonstrating any impacts, because if partitioned as such, a 5% reduction simply would not be enough to show a noticeable impact on the RSF output. Perhaps grizzly bears reach an asymptote on human disturbance beyond which increases in disturbance coefficients is not expected biologically and so a doubling in adjacent human density only translates into an additional 5% disturbance, but we do not know of such a mechanism. Either way, more details of this analysis must be presented before it can fully be evaluated.

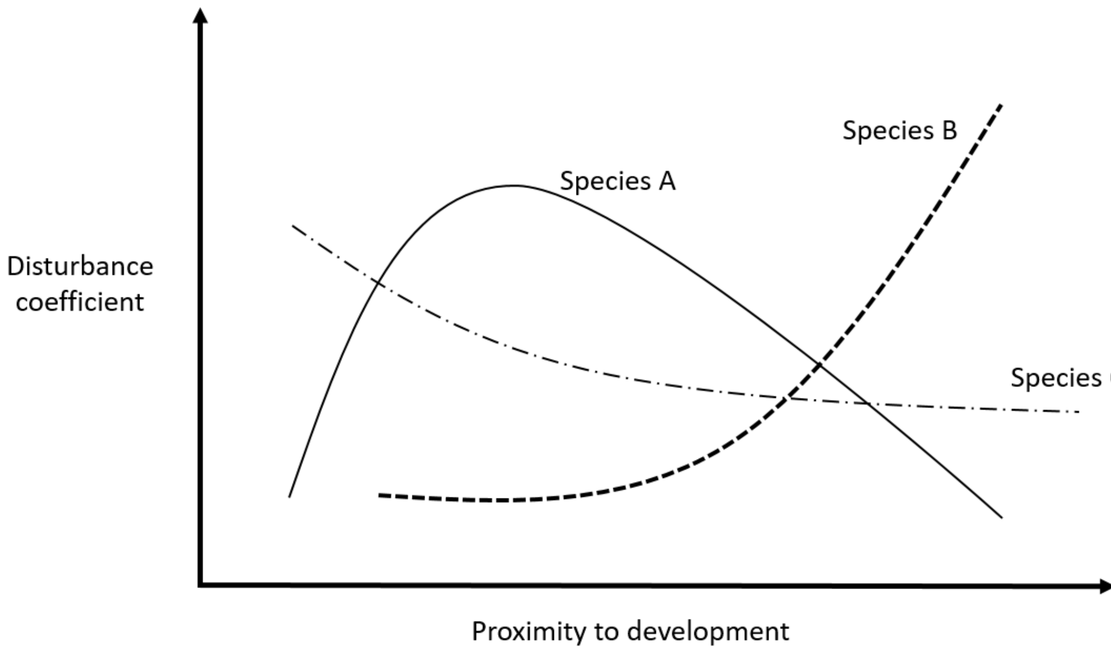
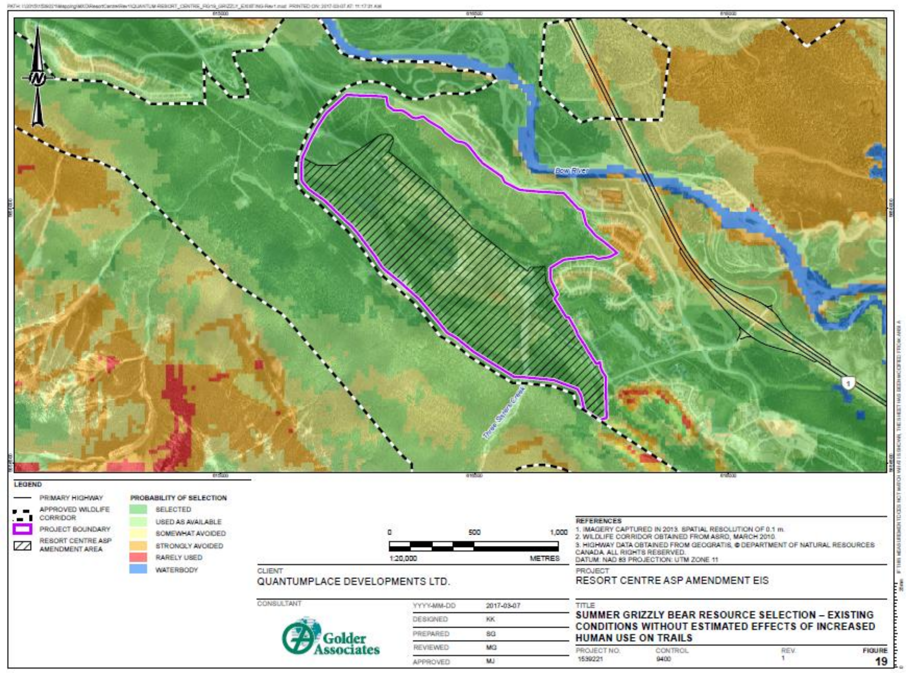


Figure 7. Hypothetical functional responses of different species showing how a model could be parameterized to translate flight initiation distances to a transparent proximity metric and ultimately into a disturbance coefficient.



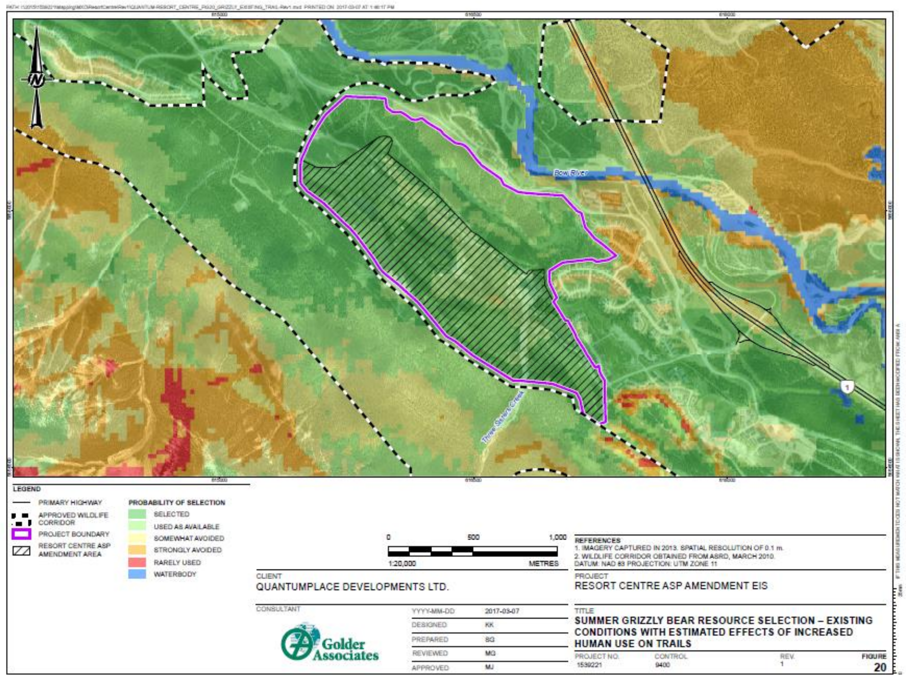


Figure 8. Comparison of the RSF output for grizzly bear habitat selection before (top) and after (bottom) human use on trails was applied to the habitat quality. The two figures show identical pre and post conditions within the Project Boundary highlighting that human use and neighborhood development have inexplicably been addressed independent of each other, even though they are inextricably linked. A correct approach would indicate simultaneous development impacts within the Project Boundary associated with corresponding expected levels of human use extending into the wildlife corridor. Instead, these two figures are essentially and functionally identical because relatively low-disturbance human use has been applied to an undeveloped Resort Center, and is then contextualized in the EIS as “human-based impacts will be negligible” which is a conclusion based upon an incorrect analysis.

A Recommendation to Improve Scenario Modeling with Connectivity Analysis

A fundamental concern regarding the EIS for the Resort Centre relates to the use of RSF models as the primary method to assess potential impacts of the development on wildlife movement. As we have noted above, RSF models are well suited for identifying locations on the landscape where preferred habitat might exist, but not how animals would travel to arrive at the preferred habitats. Connectivity modelling is a more appropriate scientific method for describing or predicting whether wildlife can effectively *move between* patches of preferred habitat. It is this *movement* between different areas of preferred habitat that we feel is the most important issue related to the proposed development. The Resort Centre has the potential to directly and indirectly impact patterns of wildlife movement in the adjacent wildlife corridor, and this remains unexplored.

Defensible RSF models could be used to partially inform a connectivity model that would provide a more relevant assessment of the existing conditions for wildlife movement within and adjacent to the Resort Centre. The output of the connectivity model could then be used as a reference-condition benchmark against which any change in wildlife movement (i.e., associated with any proposed developments) could be compared. This benchmarking is important if an adaptive management approach is being proposed, as it is critical for informing and defining management and monitoring objectives related to the development.

We maintain that a connectivity analysis should have been completed as part of the EIS, and when used within the context of scenario modeling, would have provided a great deal of information regarding the possible impacts of the proposed development on changes to the baseline conditions for wildlife movement, as well as an evaluation of how different mitigation techniques (e.g., fencing) could reduce potential impacts. Importantly, appropriate data are available to examine different scenarios of development, human population densities, fence permeability, and mitigation strategies upon wildlife movement and human-wildlife interactions directly within, and in proximity to, the Resort Centre Project boundary. All of these can be parameterized using site-specific empirical data in a predictive-modeling context to explore human-use thresholds and development scenarios and the effects these might have on wildlife. The RSF models developed in Golder (2012) are a partial step in this direction (analytical issues discussed above notwithstanding); however, without examining connectivity, this EIS does not adequately advise Town Council of the potential impacts to wildlife that may be associated with altering an Area Structure Plan directly adjacent to a wildlife-movement corridor.

A more appropriate and entirely possible assessment of the impact of human use on wildlife movement would have been to create a spatially explicit modeling environment contextualized within a connectivity analysis, whereby different levels of development intensity were explored against human-wildlife conflict and fence choice; the latter two variables parameterized using actual site-specific data on human-use levels and wildlife-movement data from the project area. Different development alternatives and their trade-offs could then be explored in a hypothesis-testing environment (e.g., Figure 9 herein) and in reference to several response variables including habitat connectivity, human-wildlife conflict, and mitigation effectiveness.

The spatial context of these explorative analyses are germane because currently the existing unfinished golf course may facilitate wildlife movement and augment the use of the adjacent corridor by wildlife, and an alteration of this will likely impact baseline wildlife movement patterns. A thoughtful and defensible approach would be to submit an application acknowledging this, while offering possible alternatives to augment existing approvals. These alternative scenarios might even result in the consideration of other potential mitigation strategies other than fencing alone.

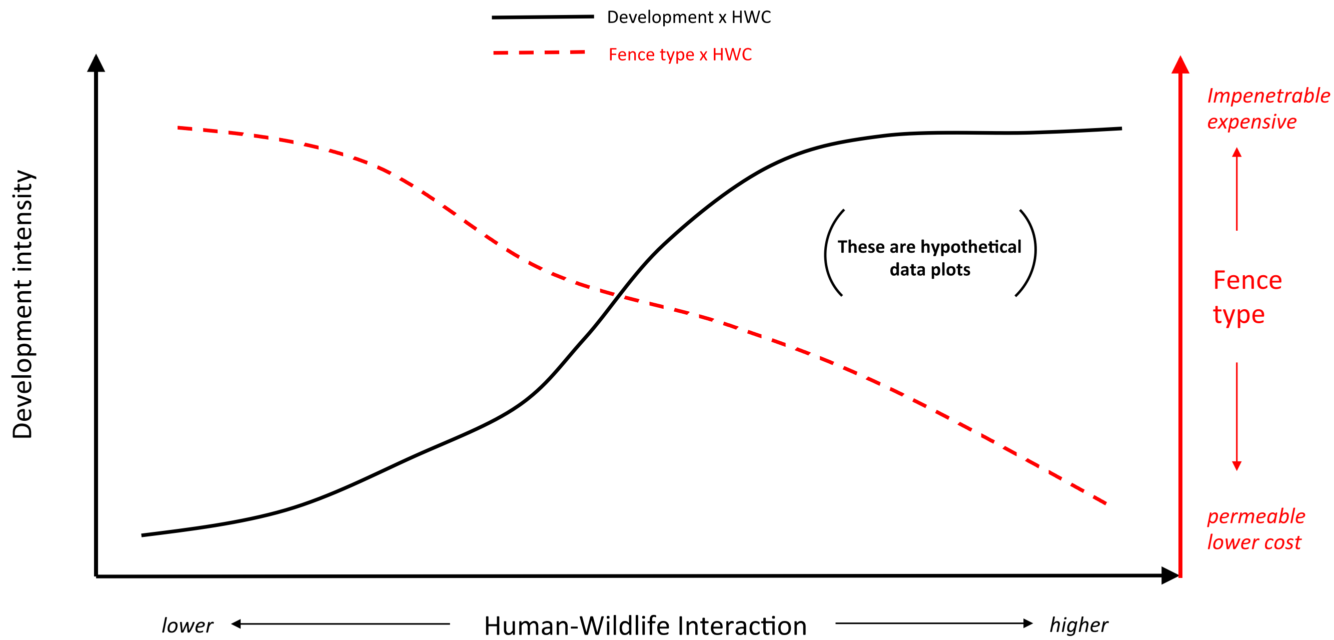


Figure 9. A possible hypothesis within which to frame a scenario-based EIS with an objective of producing unbiased evidence-based advice to decision makers. Here the potential interaction of development intensity (human density, spatial configuration) is explored regarding a primary mitigation strategy (fencing), in search of interactions and optimizations of fence type and development type versus the response variable of human-wildlife conflict.

2.4. Review of Additional VECs

The TOR for the Resort Centre EIS stipulated that an analysis of the foreseeable short, medium, and long term positive and negative impacts of the proposal be conducted for a range of additional Valued Environmental Components (VECs). The list of additional VECs that required assessment as part of this EIS included:

- Fish and associated aquatic habitat
- Vegetation
- Soils and terrain
- Groundwater
- Surface water
- Air quality
- Visual resources

For most of these VECs, a general overview and description of current conditions was provided, but in some instances there is considerable uncertainty in whether current conditions were accurately assessed.

For example, we noted that vegetation was not well-documented because inventories are likely out-dated and clarity on whether or how these were updated was vague. To assess vegetation, the EIS states that 153 vegetation surveys were completed on TSMV lands over two days in 2008, and that methods for vegetation sampling could be found in Appendix B of Golder (2013). However, we found no sampling methods there, only a description of the land-cover types, and there are no locations for the 153 surveys. Were they systematic, stratified, or distributed otherwise? Were they all on the Resort Centre? What were the survey methods and what data were collected? This information is not provided, so this must be acknowledged moving forward and perhaps updated as required.

Similarly, a viewshed analysis as requested in the TOR was not completed as part of this EIS, and this has become standard practice especially in areas with high tourism and scenic value. The Bow Corridor is world renowned for its mountain scenery, so a best-practices approach would be to examine the impact of the Resort Center amendment on visual resources. A viewshed analysis is a desktop exercise that can be completed with open-source (no cost) software and the publicly available provincial digital elevation model. Locations within a hillshade model are positioned (i.e., the Resort Core) and the software indicates from where in the area the denoted location can be seen (Figure 10 herein). This is strongly recommended at the development stage where building heights are being considered, but preliminary visual-sensitivity analyses could still be completed on undeveloped lands.

For fish, soil and terrain, and surface and groundwater, the EIS noted that there is remaining uncertainty related to predicted project effects, which they noted was related to an absence of detailed planning. While the descriptions provided for these VECs probably would meet the terms of reference for the level of detail required at ASP, the Town will likely want to request additional details or further study of some or all of these VECs as more detailed planning progresses.

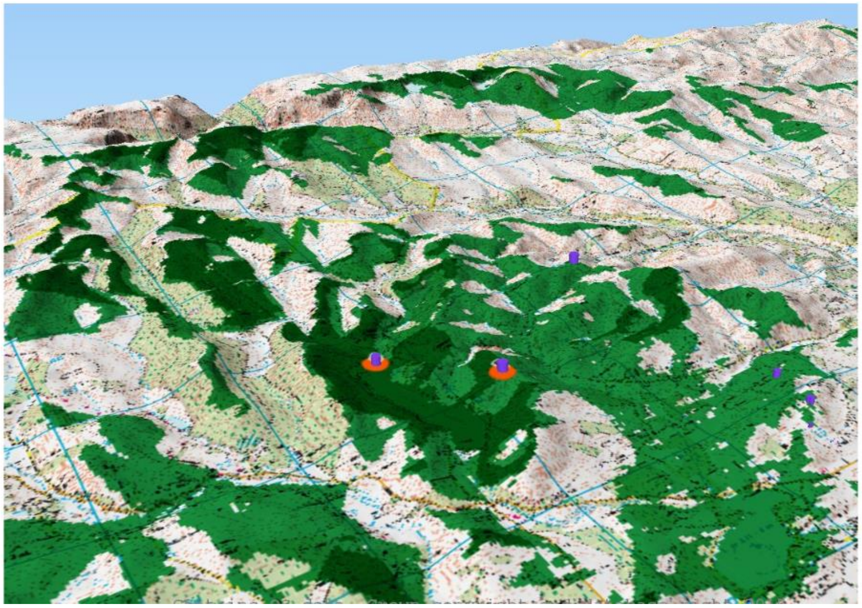


Figure 10. Example of a viewshed analysis where purple towers indicate possible structures and their heights, and the green areas indicate from where in the area these structures can be seen.

3.0 Mitigation & Monitoring

This section provides a review of the mitigation and monitoring put forward in the Resort Centre EIS to minimize residual impacts of the development of wildlife and wildlife habitat.

Section 3 at a glance. One of the major mitigations put forward for this development includes fencing, and while we note that fencing will keep wildlife out of the new community, the EIS provides little compelling information regarding the potential effectiveness of fencing (with education and enforcement) in mitigating human use impacts into the wildlife corridor. We also note that the EIS makes reference to adaptive management and monitoring, without outlining a credible framework for undertaking and linking either.

3.1. Fencing Out Wildlife versus Fencing in People

Throughout this process, fencing has prevailed as perhaps the most apparent mitigation technique, and it has been difficult to fully evaluate the proposed fencing, mainly because of the abovementioned issues of wildlife movement versus habitat selection. Fencing has a very different context depending on which existing condition (movement versus selection) is being used to address effectiveness. When challenged on the potential effectiveness of the fencing as a mitigation technique for this development, our response has always been "it depends on the potential impacts of exactly what is being developed, and these potential impacts have yet to be appropriately explored."

Notwithstanding our position on the need to appropriately assess impacts, we acknowledge that fencing can be an effective method for excluding wildlife from new neighbourhoods, which can in turn reduce human-wildlife conflict. So, if this development was a one-way directional issue of preventing animals from entering human-use areas, then "yes", building a fence will keep many wildlife species out of the development footprint; science is not required to answer that question.

Nonetheless, the EIS offers examples where wildlife fencing has worked to exclude wildlife from developed or human-use areas. These examples have included the Jackson, Wyoming Elk fence, the Lake Louise campground fence, the Trans-Canada highway fence, and Bison paddock fences in Banff National Park. These all demonstrate to varying degrees that fences keep wildlife out. However, we argue that this is not just a one-way issue of keeping wildlife out of the Resort Centre. Rather, there should be notable concern regarding the inevitable increases in human population within the Resort Centre lands, and how this population increase may translate into increased human pressure within the adjacent wildlife corridor. This is especially cogent considering that baseline wildlife-movement conditions have yet to be examined under existing Resort Center approval levels, let alone the proposed increases. And because we are referring to a wildlife corridor that has been set aside specifically to accommodate wildlife movement, we are specifically referring to an examination of how an increase in human use may impact habitat connectivity and associated wildlife movement, and potentially cause changes to the baseline patterns of wildlife movement in response to human use and residential development, and this has not been sufficiently addressed in the EIS.

Instead, the EIS discusses fencing, signage, public education, and provision of recreational opportunities (trails, off-leash parks) within the boundaries of the Resort Centre development, but does not examine their potential effectiveness in mitigating impacts to wildlife movement in the adjacent wildlife corridor, and *what might be expected if these mitigations fail*. And this is of concern because there is very little compelling information provided in the EIS that outlines how these mitigations would prevent an increase in human use of the corridor, particularly when the mitigation plan includes maintaining access points (i.e., gates) to allow people to access designated trails within the wildlife corridor from the new neighborhood. In particular, the EIS does not provide predictions of any expected reductions in human use the fencing might achieve, or whether this reduction is expected to be meaningful or below an impact threshold from the perspective of reducing cumulative effects on wildlife use of the movement corridor.

And so the fencing examples provided in the EIS become only partially relevant, because we still require an examination of the potential management issues that will inevitably precipitate *outside* the fence on adjacent lands. This concern interestingly can be illustrated in the examples provided in the EIS, namely the fence preventing elk (and other wildlife) from entering Jackson, Wyoming from the adjacent National Elk Refuge in the United States. This is an interesting digression to explore, because although the specific issues in Jackson WY are different, the big-picture context is notably similar to Canmore.

Like Canmore and the adjacent Banff Town site, animals entering town sites are an issue in Jackson, and this is articulated within the Elk Refuge Conservation Management Plan;

> *Wildlife that winter on the refuge can cause human–wildlife conflicts when they venture off the refuge and into the developed Jackson area. Of greatest concern are bison, which are large and sometimes bold animals that can exhibit aggressive behavior and be a serious threat to human safety and property. Elk can create conflicts, mostly as a traffic hazard as they cross heavily used highways or pathways when moving onto the refuge, although they can also cause property damage and threaten human safety in certain situations.* (U.S. Fish and Wildlife Service 2015)

Animals in Jackson are largely prevented from entering human-use areas and highways because the fence is there. But like Canmore there is another side of the fence (figuratively and literally), and examining this reveals several unresolved issues *within* the National Elk Refuge – something analogous to the potential wildlife and human-use issues that will arise post-development within the adjacent wildlife-movement corridor. In the Jackson example we can find many on-going *management*-related conflicts in the Elk Refuge on whether stakeholders have been properly engaged and on whether management scenarios have been fully examined. Of course, the detailed issues are different (e.g., supplemental feeding of elk), but many are very similar (e.g., eco-tourism, hunting, and recreation within the fenced refuge, amongst others) and the over-arching lessons are perhaps worthy of pause. Neff (2007) captures these effectively;

> *The National Elk Refuge in Jackson, Wyoming [is] an example of a seemingly intractable dispute in which scenario planning could be applied to great benefit and where other, more linear approaches to planning have failed to defuse contention. The elk herds, the ecosystem in which they reside, and the local economy are interdependent components of a social–ecological system. Social and economic pressures make it difficult for managers to make proactive changes to the management regime that would increase the resilience of the*

system; any change is likely to be challenged by stakeholders who perceive that their short-term interests are harmed.

To create resilient systems, plans must consider to a variety of possible futures. Past decisions about elk management have been marked by lawsuits between various groups including state and federal agencies and interest groups trying to serve the needs of their constituencies. The proposed alternatives described in the Environmental Impact Statement that change current management would likely benefit some stakeholders at the expense of others, suggesting that the outcome of the current planning process will be similarly contentious. In scenario planning, scientific knowledge can be combined with stakeholder knowledge and concerns to create stories about the future against which proposed plans can be evaluated. Were it applied to this contentious system, the process might help to generate the type of consensus that would allow for anticipatory management. (Neff 2007)

It is more than noteworthy that those involved with environmental assessment work in Jackson WY espouse the careful use of scenario modeling as an effective method to engage stakeholders and inform complex decisions. In fact, when we move away from the "fences work well to keep animals out" and rather use Jackson as an example of how the whole management-planning EIS structure, and not just the wildlife fence, could be improved then relevant lessons are revealed that are highly applicable to the Bow Valley. We have attempted to recommend some of these in this review within the context of scenario modeling.

Further, there are other mitigation issues that could be better examined in the EIS. For instance, although education and enforcement is proposed as a mitigative technique to prevent recreational over-use of the wildlife corridors, there is no examination of whether we should expect this to be effective. The modeling scenarios examining human-use assume that education and enforcement will be 100% effective in preventing recreation on non-designated trails, but this requires considerable confidence in provincial enforcement resources. Even current recreation levels on these lands are striking, and so we question just how effective education and enforcement would be post-development. Can trail closures actually be effective? And, what happens if enforcement fails? What might stakeholders expect as a management issue?

Similarly, what might happen when we examine the interaction of fencing and human use? There might be interesting trade-offs revealed in examining "enforcement-only" strategies compared to "fencing plus enforcement", or even "just fencing." If these three mitigation strategies could be examined using a range of possible human-use levels, then we might have some indication of the relative contribution each mitigation might provide, and this would be very interesting when assessed against the possible development scenarios. A range of different mitigation scenarios could have been explored in the EIS to provide a more fulsome exploration of potential impacts and possible mitigation success.

Throughout this review process, a fundamental recommendation we made was to examine how different intensities or spatial configurations of development might affect existing conditions of wildlife movement both within and adjacent to the ASP boundary. Inherent in this approach was the understanding that an increase in the number of units would result in an increase in neighbourhood population, which would in turn translate into and increase in human use within the adjacent wildlife corridor. In addition to this, we argued there would be three components to examine for any development scenarios being considered;

1) Direct habitat changes from developing and fencing the unfinished golf course, and the indirect effects of sensory disturbances (e.g., light, noise, odors) penetrating into the adjacent wildlife corridor;
2) Human-wildlife conflict outside the development boundary from an increase in human use of the adjacent wildlife corridors, and;
3) The effectiveness of suggested mitigation techniques.

To link these components together effectively, we suggested an exploration of potential development scenarios while modeling changes in both direct and indirect effects, and their mitigation effectiveness, primarily on how the adjacent wildlife corridor might be shifted from its existing condition. Our intent for suggesting this approach was to encourage the linking of mitigation, monitoring, and adaptive management. For example, there was notable emphasis in the EIS placed upon camera monitoring of human use throughout the Bow Valley, but no exploration of the possible thresholds of human use that might trigger a negative shift in wildlife movement patterns away from baseline conditions. As a result, we recommended an examination of both direct habitat loss from developing the unfinished golf course, and an examination of indirect effects associated with these developments (e.g., light, odours, human use), as this examination would be a strong metric linking observed levels of human recreation to some proposed mitigation strategies to be included in this EIS. Ultimately we received only a partial examination of these issues, and one that we felt was disconnected from planned development, and thus, from monitoring and how monitoring was to inform adaptive management.

3.2. Alternative Mitigation Techniques

The general mitigation techniques suggested in the EIS in themselves are not inappropriate, but as proposed, we could envision significant issues in their implementation which we argue is not well examined. Within the context of our role as a Third Party Reviewer, we submit that offering suggestions for alternative mitigation strategies would not be helpful because: (a) how the system is to be expected to alter from baseline conditions is largely unresolved, and (b) the suite of suggested techniques has not fully been explored with realistic effectiveness (i.e., not assumed to be 100%). This leaves three important routes of examination that should be completed prior to requesting any new mitigation techniques.

First, fencing a neighborhood may have serious implications for current patterns of wildlife movement through the study area, and the existing conditions of movement through the Resort Centre and associated corridors lands have not been appropriately examined. If there is any concern over creating pinch-points for wildlife movement, or concern over how close to an ecological threshold the adjacent wildlife corridors might already be in their current state, then this should be assessed *a priori* with scenario modeling and not *post facto* as a landscape monitoring experiment with largely unknown consequences.

Second, the exact placement of the fence within the neighborhood has not been examined with respect to the indirect effects on wildlife of noise, light, and odors and how these may vary depending on the actual development. The EIS started to examine indirect effects using flight-initiation distances for species using the wildlife corridor, but did not apply these to the development footprint or to other known trails. So there remains a high level of uncertainty on exactly how far indirect disturbances might extend into adjacent lands, and how the fence might be placed to mitigate these effects. For instance, if the neighborhood is built right up to the ASP boundary and thus right up to the fence – and we have good reason to believe this will occur (e.g., EIS's Figure 6 indicates resort accommodation directly adjacent to the proposed fence) – then we are still not clear on how this may affect the adjacent corridor, and whether the proposed mitigations could actually control this impact. And we should reiterate that this potential impact is best articulated within the context of wildlife movement, and not just with respect to habitat quality.

Third, given the current human-use level in the adjacent corridor, it remains unclear whether the proposed mitigations largely captured under “education and enforcement” would be effective in the current state, let alone in the future potential developed state. At the least, an *a priori* assumption that these mitigations will be 100% effective is unrealistic, so there remains much uncertainty regarding how the current state of human use in the corridor might change, and how this change will impact wildlife movement patterns. Moreover, a thorough examination of this mitigation would include some assessment of whether involvement of the relevant stakeholders, in this case either Fish and Wildlife Officers or Conservation Officers employed by the Province, is realistic in terms of having the resources and capabilities to mitigate human-use impacts on provincial lands resulting from this development. An important question to ask as part of any proposed mitigation approach is whether the mitigation is realistic, and what may happen if in this case, education and enforcement fails entirely? And this is a good example of how monitoring data must be clearly communicated to articulate a baseline condition, which can then be used to engage stakeholders and inform a management decision.

The EIS has proposed mitigation techniques that are appropriate in the context of a residential development in the Bow Valley; however, the mitigation plan notably lacks a realistic implementation strategy. As such, it is not that we think the proposed mitigations are inappropriate, as much as we are concerned they are not strongly linked to logistical realities, baseline conditions, or an understanding of pragmatic effectiveness. This is where the structured decision-making of adaptive management becomes important.

3.3. Linking Mitigation, Monitoring, & Adaptive Management

This EIS contains many of the challenges associated with effectively linking baseline-monitoring data to impact assessment analysis, and ultimately using these to inform adaptive management (Figure 11). Adaptive management identifies uncertainties, and then establishes methodologies to test hypotheses concerning those uncertainties. It uses management as a tool not only to change the system, but as a tool to learn about the system through experimentation and monitoring. It is important to recognize how this fundamentally differs from best-guess trial and error, and how the objectivity in defensible assessments can promote political openness and social cohesion amongst stakeholders.

As we have stated, the data and resources exist to develop a measure of existing wildlife movement and habitat connectivity, which can then be used as a performance indicator in evaluating possible development proposals and their potential to alter human-use levels, change corridor effectiveness, or create environmental conditions significantly different from existing conditions. There are even existing monitoring programs from which realistic estimates of human and wildlife use can be acquired and integrated in to scenario modeling. Through this integration, management could be altered as informed by monitoring data and a careful assessment of development trade-offs. But it is important to recognize the order in which these events occur and exactly how they are related back to recommended changes in management.

Prior to making an informed decision, current conditions must be quantified in reference to agreed-upon evaluation criteria. If there are disagreements as to what these criteria are, then the outcomes and trade-offs cannot effectively be evaluated. In the case of Resort Centre, there appears little overarching consensus or direction regarding the primary criteria against which to evaluate development; some argue wildlife movement and habitat connectivity are important, while others argue that direct habitat loss and proximal habitat selection are important. This needs to be resolved before adaptive management can proceed.

Further, there is no consensus as to whether the existing wildlife corridors facilitate effective wildlife movement in their current state, let alone how developing the golf-course lands will change existing conditions. As such, the Resort Centre application is effectively proposing to implement a change without first establishing existing conditions as measured though an agreed-upon indicator or performance metric. By doing so, the adaptive management cycle is entirely truncated and the whole structured decision-making component (the right-hand side of the adaptive management cycle in Figure 11) is incomplete and non-functional. The discrepancies or debates over wildlife movement versus habitat selection represent an adaptive management process whereby the learning (i.e., Figure 11) is not effectively informing the structured decision making. Of course with the legal history of the TSMV lands, Figure 11 is a simplification of the Resort Centre context; however, regardless of complexity these basic components remain, and with proper stakeholder agreement in defining the problem, any future EIS's are likely to be more informative, less expensive, and more productive.

Further, with any suggested monitoring program, there needs to be a clear linkage on how monitoring data are used to inform management. The Resort Centre EIS recommends continued monitoring of wildlife corridors for people, wildlife, and their negative interactions, but it gives little direction on how to integrate these data into management. A possible improvement to this would be to use a connectivity modeling construct as a response variable against which to examine human use in the wildlife corridors, whereby all the camera and wildlife data described in the Resort Centre EIS could be integrated with a connectivity model, and some possible thresholds identified where we might expect development or human use (or both) to impede connectivity. In this sense, a measurement of connectivity becomes a baseline condition against which change is measured. This also provides targets and known accuracy to inform a monitoring program, such as;

- How often to sample;
- How intensely to sample;
- The spatial extent of sampling;
- The data-management requirements;
- The statistical analyses required, and;
- The required collaboration among stakeholders to maintain monitoring efforts.

A key to this monitoring in the context of development is some understanding of current state, and whether that current state is already beyond any thresholds that would require changes in management. If thresholds have yet to be reached, then how much development might we undertake (along with mitigation) before we get close or beyond a threshold? This was a key missing variable in the Resort Centre EIS: a convincing assessment of existing wildlife movement within the Bow Valley. Knowing this would inform both mitigation strategies and future monitoring, which would also inform development *per se*. Within this construct, development planning in the Bow Valley could take a large step forward.

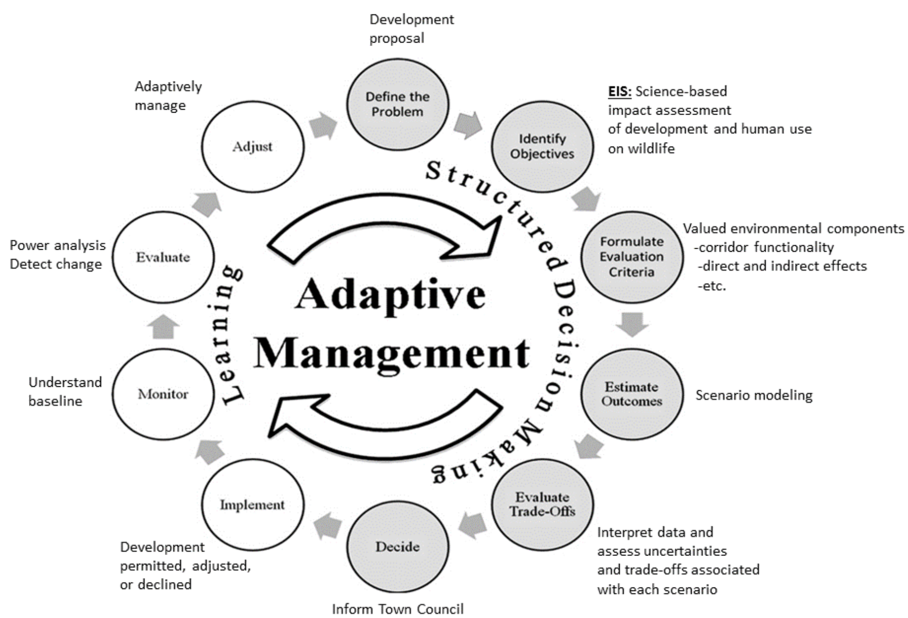


Figure 11. The important links between an EIS, scenario modeling, effectiveness monitoring, and adaptive management.

4.0 Scientific Conclusions

4.1. General Summary

The primary objectives of this third party review were to evaluate the Resort Centre EIS to ensure that it met the following conditions and requirements outlined by the Town of Canmore:

1) That the EIS is complete, as per the project-specific Terms of Reference;
2) That the scientific basis for the assessment of impacts is appropriate;
3) That the conclusions drawn with respect to impacts appropriately reduce uncertainty related to how the proposed project will impact Valued Environmental Components (VECs);
4) That the mitigation and monitoring proposed is appropriate in light of the anticipated impacts.

The EIS chose to document baseline conditions using Resource Selection Function (RSF) models which examine an animal's habitat selection, not their movements. Because of the adjacent wildlife-movement corridor, we argue that baseline conditions should be evaluated using a connectivity analysis, which would better contextualize and address potential impacts of the Resort Centre ASP amendment.

We also raise cautions with the methods used to develop the RSF models. Specifically, we caution the validity of the RSF models based on discrepancies between the dates animal telemetry data were collected versus the dates land covers were created. We also found discrepancies in how the land cover data were created and how habitats therein were classified. This has potentially marked implications for the RSF outputs, validity, and uncertainty, but remain largely unreported in the EIS. Similarly, we also noted some missing components in the habitat models that made them difficult to interpret ecologically, and thus we argue they are hard to contextualize regarding impact assessment.

The scenario modeling employed to examine human use was only completed for one of five presented scenarios, and alternative scenario were not explored nor linked to potential unit densities, expected populations densities, or associated human-recreation impacts within adjacent lands. Regarding impact mitigation, fencing the development is suggested but is only discussed as it relates to keeping wildlife out of neighbourhoods, not in meaningfully keeping people from impacting adjacent wildlife corridors; the latter being arguably of equal or more concern. And, additional mitigations of "education and enforcement" are assumed to be 100% effective which we consider unrealistic, and there is no contingency offered if mitigation is less than 100% effective, nor are the potential impacts of this shortfall examined within a decision-informing context. That is, although the suggested mitigation techniques are generally appropriate, we felt the EIS fell short in offering a meaningful *implementation* of these mitigations clearly linked to reference conditions, possible impacts, and how these are integrated into adaptive management; all of which add uncertainty to the proposed ASP amendment.

4.2. Uncertainties Remaining in the Resort Centre EIS

While the EIS that was submitted for the Resort Centre does provide information on a wide range of environmental issues and species of conservation concern, it is our opinion that the EIS does not provide an evaluation of the *relevant* issues, and thus lacks sufficient information to reduce the uncertainty regarding the potential impact of the proposed development.

The primary uncertainties that are unaddressed by this EIS are as follows:

- The EIS quantifies baseline conditions using habitat selection and not wildlife movement, and we cannot infer from the results provided how wildlife movement might be impacted.
- More work remains to better define existing conditions as they relate to wildlife movement, as well as to explore how a range of both increases (as a result of development) and decreases (in response to successful mitigation) in human use would change wildlife movement patterns. We reiterate here that a connectivity analysis is the preferred method and that all of the data required to do this type of analysis are available to the proponent, and it is our opinion that this analysis would help to illuminate questions regarding human use and the potential impact that this development could have on wildlife in the study area in a meaningful way.
- The methods used to create the land cover which forms the basis of the RSF models and thus the benchmark of change and potential impacts, are unclear and some aspects of the RSF modeling itself are questionable. Combined, these issues reduce our confidence regarding the accuracy of the model predictions in assessing the impact of the proposed development. More clarity regarding the methods used for the modeling, and a rationale explaining the reasons for the inconsistencies we observed, is required.
- The EIS focuses on quantifying the direct impacts of the proposed development via changes in habitat quality, but is insufficient in its analysis of the direct and indirect effects attributable to associated increases in human recreation of the wildlife corridor. The EIS suggests that mitigation of human use in the corridor will be completely effective and falls short in examining alternatives if mitigation fails.
- The mitigation put forth sufficiently addresses issues related to keeping wildlife out of the development by fencing the neighbourhood; however, more work is required to examine fence placement particularly in the context of wildlife connectivity. Further, the EIS presents no compelling evidence that the fence and education and/or enforcement will be 100% effective in mitigating management issues in the adjacent lands.
- The proposed monitoring program lacks an appropriate level of detail linking it effectively to adaptive management. While we acknowledge that it is difficult to provide an extensive level of monitoring detail at the ASP stage, we feel that a more comprehensive framework for monitoring could have been provided.

A summary of these key uncertainties are provided in Table 2.

Table 2. Remaining sources of uncertainty in the Resort Centre EIS and suggested approaches to address each.

Key Uncertainty	Source of Uncertainty	Suggested Approach to Address Uncertainty
Existing condition of wildlife-habitat quality is potentially unknown.	• There are uncertainties in how land cover data were classified and then integrated in to the RSF modeling process. • The wildlife-habitat models are unclear in their presentation, lack hypotheses, and are built upon questionable land cover data.	• Provide additional information to explain the inconsistencies in land classifications and model outputs between 2012, 2013, and 2017. • Clarify the hypotheses and mathematical relationships associated with every candidate model and selected model included in the RSF analysis.
Existing condition of wildlife movement within the Resort Centre ASP boundary and the adjacent wildlife corridor has not been assessed.	• A scientifically valid method for assessing wildlife movement has not be used.	• Use a connectivity model to assess current patterns of movement of key wildlife species through the Resort Centre and adjacent wildlife corridor. • Use existing telemetry data to validate the connectivity models and assess confidence in model predictions.
Existing condition of human use in the wildlife corridor has not been adequately defined.	• Existing human use data has only been summarized but not analyzed to quantify defensible human-use conditions. • Human use and development were examined independently, even though they are inextricably linked.	• Do a statistical analysis of the human use data to provide estimates of the number of users, the intensity of use of trails in the corridor, and the increase or decrease of users over time to establish baseline conditions of human use which can then be linked to wildlife data and to mitigation-effectiveness monitoring.
Neither existing nor predicted human use has been integrated with wildlife movement data.	• The predicted effect of increased human use in the corridor has been evaluated using habitat selection instead of wildlife movement. Further, existing human-use data have been overlooked in favor of professional judgment.	• Use connectivity modeling to examine a number of different development scenarios that represent small, moderate, or large increase or decrease in human use of designated and non-designated trails on wildlife movement patterns.
The effectiveness of the mitigating regarding human-wildlife issues within the wildlife corridor remains unknown.	• The predicted effects of human use post-development assumes 100% effectiveness in mitigating off-trail recreation, and whether fencing and public education will achieve this level of compliance is highly questionable.	• Examine a range of potential mitigation effectiveness to inform both monitoring-data interpretation and subsequent adaptive management frameworks.

5.0 Closure

This report was written by:

Fiera Biological Consulting Ltd.

Matthew Wheatley, PhD
Sr. Scientist, Applications & Research

Shari Clare, PhD, PBiol
Director, Sr. Biologist

ALBERTA SOCIETY of Professional Biologists
SHARI L. CLARE
1095
PROFESSIONAL BIOLOGIST

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