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Modeling and management of potential movement for elk (Cervus elaphus), bighorn sheep (Ovis canadensis) and grizzly bear (Ursus arctos) in the Radium Hot Springs S area, British Columbia

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Abstract

I delineated potential movement corridors for elk (Cervus elaphus nelsoni), bighorn sheep (Ovis canadensis canadensis) and grizzly bear (Ursus arctos) using a GIS-based modeling approach. This approach incorporated current modeling techniques complemented by site-specific knowledge of wildlife use acquired through an extensive review of the literature, key informant interviews and personal observations in the field. My analysis led to the identification of 18 potential corridors for elk and/or grizzly bear and 12 potential corridors for bighorn sheep. Three corridors stand out as being particularly important for ensuring connectivity on a regional scale, for multiple species. The Upper Luxor Creek Corridor provides the only low elevation, forested linkage between the Kootenay and Columbia drainages within the study area that is relatively secure from human disturbance. The Upper Benchlands Corridor offers a high quality corridor for movements along the Columbia Valley and, because of its width and gentle topography, is probably suitable for a wide variety of species. This corridor is of particular significance because it provides a safe route for animals traveling between the Columbia Valley and Kootenay National Park via the Lower Sinclair Creek Corridor. The Lower Sinclair Creek Corridor represents another important low-elevation forested linkage between the Columbia and Kootenay Valleys. Empirical data and anecdotal observations demonstrate movement of bighorn sheep, elk, wolf and cougar through this corridor. The main issues threatening habitat connectivity in the Radium area are increasing recreational and residential development, blockage of movement and mortality associated with transportation corridors, and a lack of coordinated regional planning. General recommendations aimed at preserving a functional network of corridors across the greater Radium landscape include the formation of a sub-regional ecosystem advisory committee, the formation of a sustainable economy committee, the establishment of an inter-jurisdictional wildlife database and more extensive monitoring of wildlife movements. I also provide specific recommendations relating to each of the focal species as well as to each potential corridor identified. Recommendations for future research and management are also presented.

MODELING AND MANAGEMENT OF POTENTIAL MOVEMENT FOR ELK (*CERVUS ELAPHUS*), BIGHORN SHEEP (*OVIS CANADENSIS*) AND GRIZZLY BEAR (*URSUS ARCTOS*) IN THE RADIUM HOT SPRINGS AREA, BRITISH COLUMBIA

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Note: The following paper is a summary of a Master's Degree Project prepared in partial fulfillment of the requirements for the M.E.Des. degree from the Faculty of Environmental Design, University of Calgary, Alberta, Canada. The full version can be downloaded from the Web at: www2.mtroyal.ab.ca/~mtremblay.

Abstract: I delineated potential movement corridors for elk (*Cervus elaphus nelsoni*), bighorn sheep (*Ovis canadensis canadensis*) and grizzly bear (*Ursus arctos*) using a GIS-based modeling approach. This approach incorporated current modeling techniques complemented by site-specific knowledge of wildlife use acquired through an extensive review of the literature, key informant interviews and personal observations in the field. My analysis led to the identification of 18 potential corridors for elk and/or grizzly bear and 12 potential corridors for bighorn sheep. Three corridors stand out as being particularly important for ensuring connectivity on a regional scale, for multiple species. The Upper Luxor Creek Corridor provides the only low elevation, forested linkage between the Kootenay and Columbia drainages within the study area that is relatively secure from human disturbance. The Upper Benchlands Corridor offers a high quality corridor for movements along the Columbia Valley and, because of its width and gentle topography, is probably suitable for a wide variety of species. This corridor is of particular significance because it provides a safe route for animals traveling between the Columbia Valley and Kootenay National Park via the Lower Sinclair Creek Corridor. The Lower Sinclair Creek Corridor represents another important low-elevation forested linkage between the Columbia and Kootenay Valleys. Empirical data and anecdotal observations demonstrate movement of bighorn sheep, elk, wolf and cougar through this corridor. The main issues threatening habitat connectivity in the Radium area are increasing recreational and residential development, blockage of movement and mortality associated with transportation corridors, and a lack of coordinated regional planning. General recommendations aimed at preserving a functional network of corridors across the greater Radium landscape include the formation of a sub-regional ecosystem advisory committee, the formation of a sustainable economy committee, the establishment of an inter-jurisdictional wildlife database and more extensive monitoring of wildlife movements. I also provide specific recommendations relating to each of the focal species as well as to each potential corridor identified. Recommendations for future research and management are also presented.

Introduction

The area surrounding Radium Hot Springs in the Upper Columbia Valley of southeastern British Columbia supports a diversity of wildlife species including bighorn sheep, elk, mule deer, white-tailed deer, grizzly bear, black bear, cougar, bobcat, badger, wolf and coyote. Federal and provincial land managers, however, are increasingly concerned about the loss, alienation and fragmentation of habitat as well as the disruption of movement corridors that may be occurring as a result of ever-increasing residential and recreational development across the landscape. One of the main problems to date has been the lack of coordinated regional planning. This is an issue because many wildlife species present in the Radium area travel extensively in their efforts to meet their biological requirements. Through their movements, wildlife typically cross multiple jurisdictions, each of which have different policies toward wildlife conservation. A piece-meal approach to land-use planning will inevitably lead to the fragmentation of wildlife habitat and populations, which in turn could lead to loss of species diversity.

The purpose of this study was to develop management recommendations aimed at preserving or enhancing the effectiveness of movement corridors within the Radium Hot Springs area for elk, bighorn sheep and grizzly bear. The study focused on the effects of human activity and development within the study area.

Study Area

The study area, which is represented in Figure 1, is centred on the town of Radium Hot Springs in the Rocky Mountain Trench of southeastern British Columbia. It covers an area of approximately 350 km^2. The study area can be divided into three physiographic zones: the Columbia River floodplain, the benchlands, and the Rocky Mountains. These zones lie at elevations of approximately 800, 800-1000 and 1000-2600 m, respectively. The study area includes lands that fall under a number of jurisdictions including federal (i.e. Kootenay National Park), provincial and private lands. Two major highways (93 and 95) as well as a railway traverse the study area. The Village of Radium Hot Springs represents the main settlement in the study area with a permanent population of 530 in 1990 (Radium Hot Springs 2000). The primary land uses on provincial and private lands are cattle grazing, Christmas tree farming, and recreational developments.

Fig. 1. Map and location of study area in southeast British Columbia.
(Source of base map: Ministry of Energy Mines and Resources Canada 1984).

Methodology

General Approach

I delineated potential movement corridors for each of the three focal species using a GIS-based modeling approach that incorporated current modeling techniques complemented by site-specific knowledge of wildlife habitat use and movements acquired through an extensive review of the literature, key informant interviews and personal observations in the field.

Modeling Corridors for Elk

The approach I used for modeling elk corridors was inspired by the habitat effectiveness model developed by Bighorn (1996). Bighorn (1996) provided a useful framework for delineating areas of highest effective habitat, i.e. areas of highest habitat value after human disturbance has been factored in. To this, I added a movement component to account more fully for the selection of preferred travel routes connecting areas of high habitat effectiveness. Thus, the elk model contained three components or sub-models: a habitat routine, a human disturbance routine and a movement routine. Figure 2 provides a conceptual representation of this model.

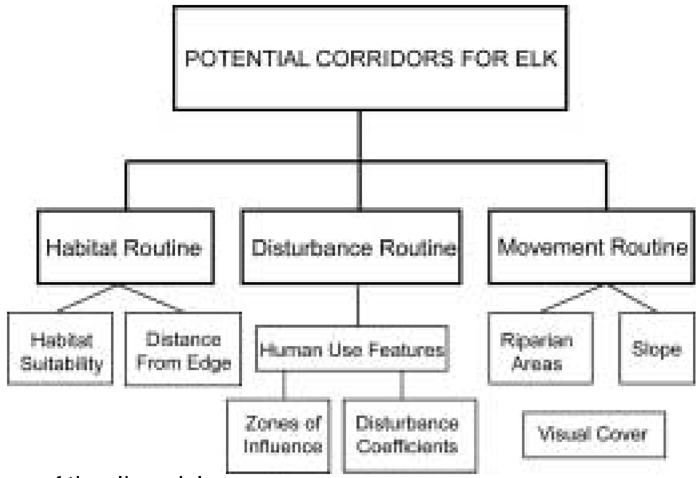

Fig. 2. Conceptual diagram of the elk model.

Modeling Corridors for Bighorn Sheep

The methodology used for delineating potential corridors for bighorn sheep followed very closely that used for elk. Some modifications were necessary, namely in terms of the choice of variables and coefficients, to account for differences in species ecology and behavioural response to human disturbance. The overall approach was also consistent with the work by Smith et al. (1990), who proposed a step-by-step methodology for evaluating bighorn sheep habitat in the Western Rocky Mountains and Great Basin regions of the U.S. Figure 3 provides a conceptual representation of the sheep model. Like the elk model, it was organized into a habitat, disturbance and movement routine.

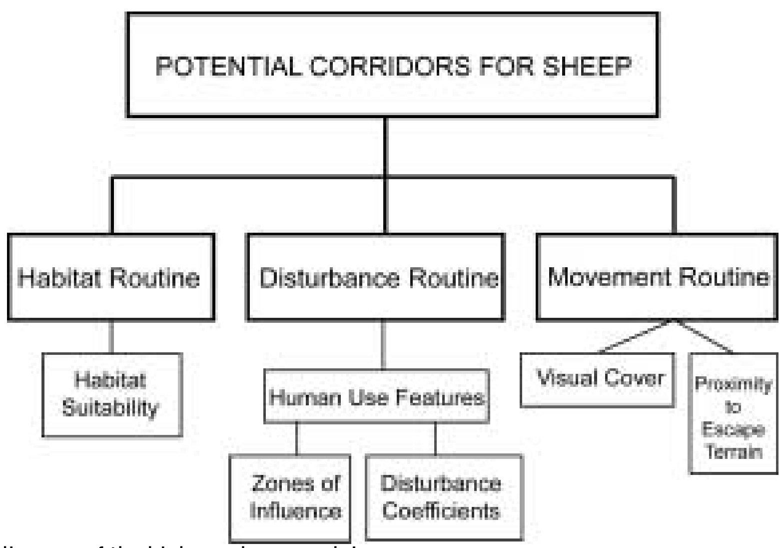

Fig. 3. Conceptual diagram of the bighorn sheep model.

Modeling Corridors for Grizzly Bear

The methodology followed for the delineation of potential grizzly bear corridors consisted largely of the application of two existing models to the study area: the core security area model (Gibeau and Herrero 1998) and the linkage zone prediction model (Servheen and Sandstrom 1993, Gibeau et al. 1996, Apps 1997, Kansas and Collister 1999). The first model is useful for delineating secure areas for grizzly bears and takes into account human disturbance as well as elevation and land cover types. The linkage zone prediction model is used to delineate linkage zones and takes into account human disturbance and, to a lesser degree, food sources and hiding cover. Both these models were originally developed specifically for grizzly bear of the Rocky Mountains, in conditions very similar to those found in the study area, and as such, they were applied without any substantial modifications to the original methodologies. However, the above models do not account for actual travel lanes that grizzly bears may select in their movements across the landscape. In order to overcome this shortcoming, a simple movement routine was added to the overall grizzly bear model. Figure 4 provides a conceptual representation of this model.

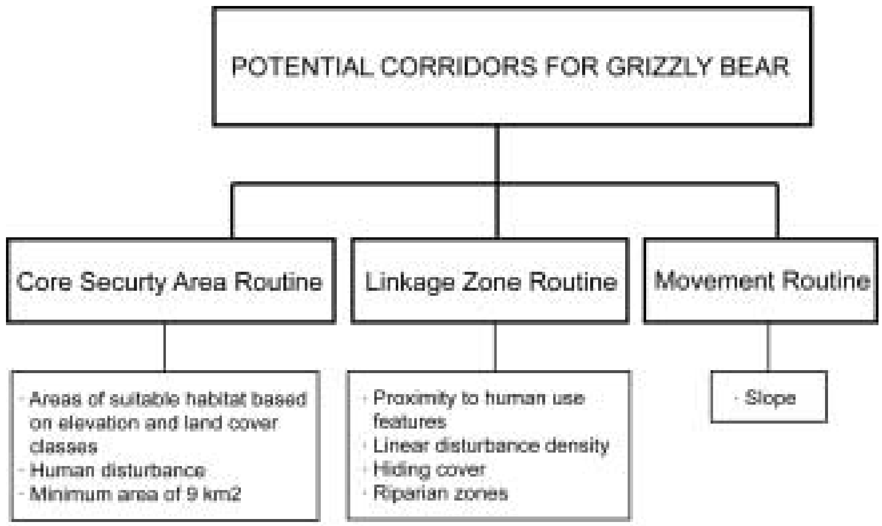

Fig. 4. Conceptual diagram of the variables incorporated into the grizzly bear model.

Results

The final output of the modeling exercise consisted of a series of maps depicting, on a seasonal basis, corridor values across the study area for each of the focal species (Fig. 5 to 7). "Corridor value" can be viewed as the suitability of an area to support the movements of individuals of a given species. Interpretation of these model outputs led to the creation of two maps of potential movement corridors: one for elk and grizzly bear (Fig. 8) and another for bighorn sheep (Fig. 9). In all, I identified 18 potential corridors for elk and/or grizzly bear and 12 potential corridors for bighorn sheep. I also described each corridor in terms of its physical characteristics and discussed its potential functions as a travel route for the focal species in question.

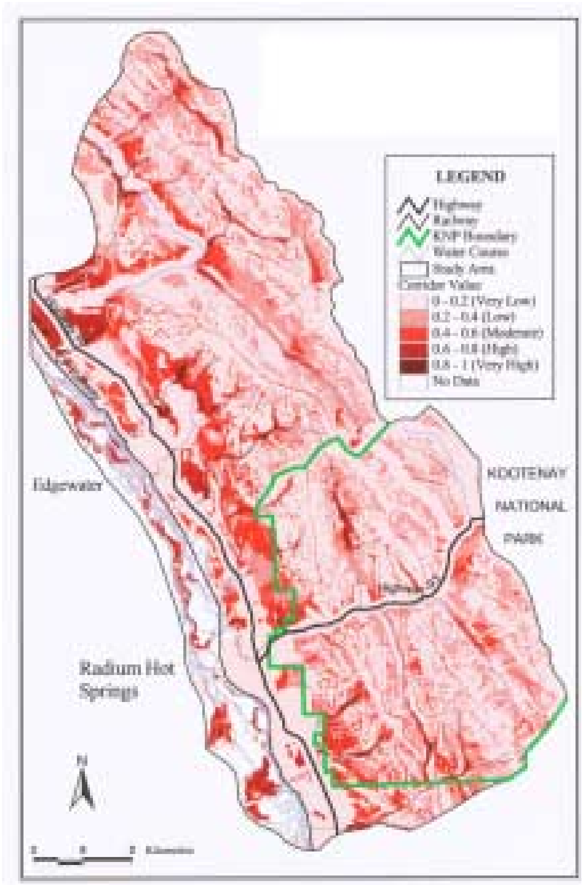

Fig. 5a. Summer corridor values for elk. Values correspond to the suitability of a given area to support the movements of elk and represent the final output of the elk model.

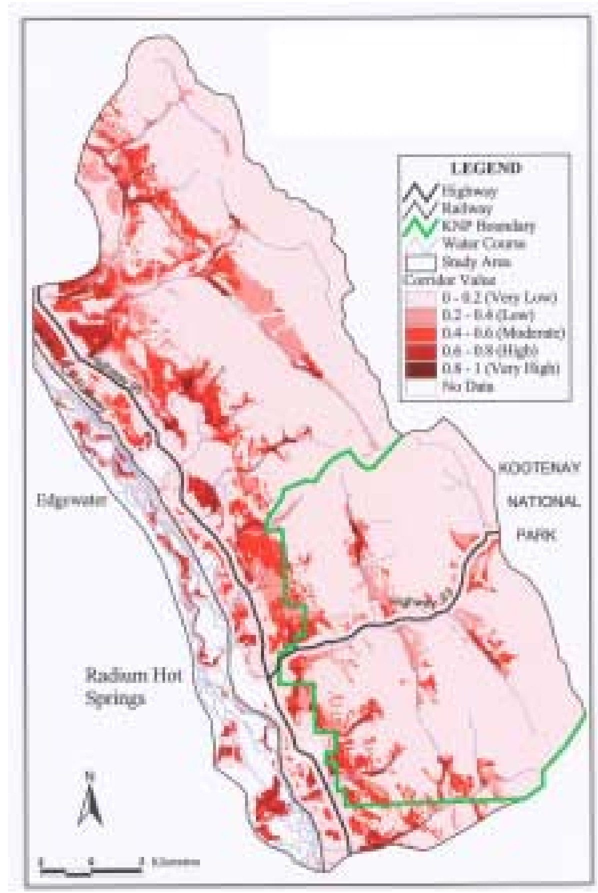

Fig. 5b. Winter corridor values for elk. Values correspond to the suitability of a given area to support the movements of elk and represent the final output of the elk model.

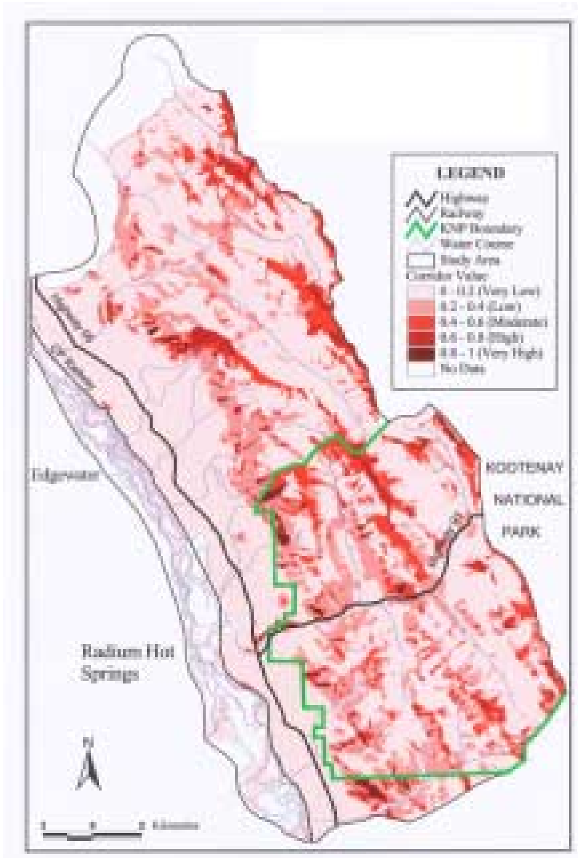

Fig. 6a. Summer corridor values for bighorn sheep. Values, which correspond to the suitability of a given area to support the movements of bighorn sheep, represent the final output of the sheep model.

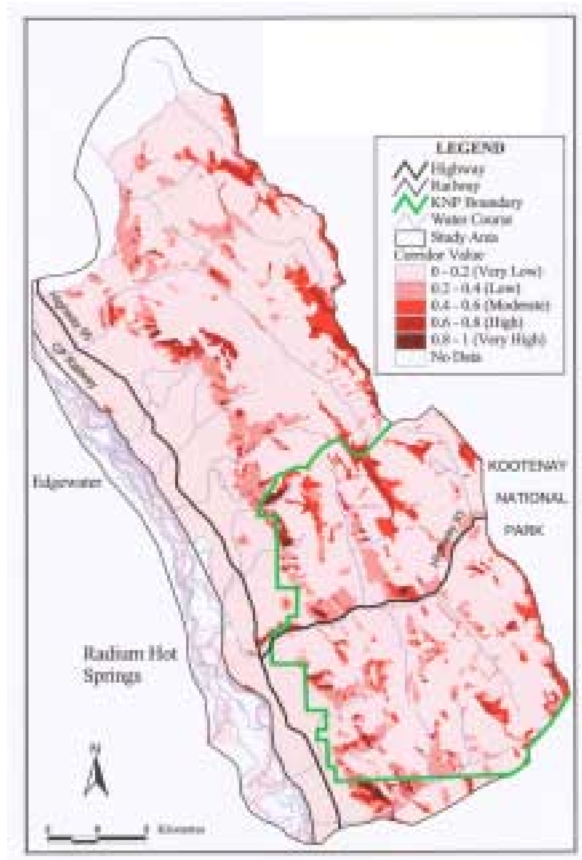

Fig. 6b. Winter corridor values for bighorn sheep. Values, which correspond to the suitability of a given area to support the movements of bighorn sheep, represent the final output of the sheep model.

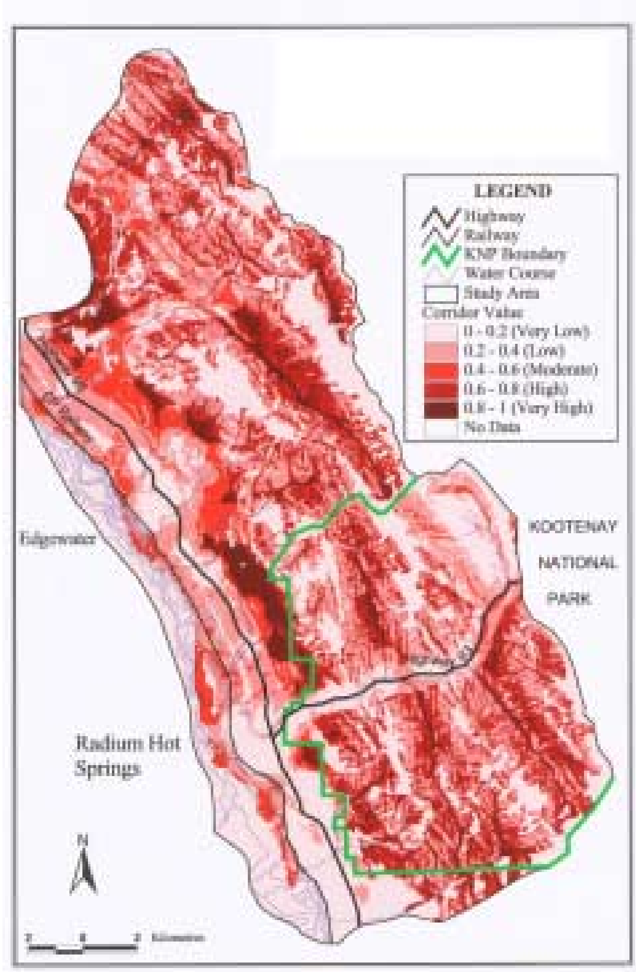

Fig. 7. Corridor values for grizzly bear. Values, which correspond to the suitability of a given area to support the movements of grizzly bear, represent the final output of the grizzly bear model.

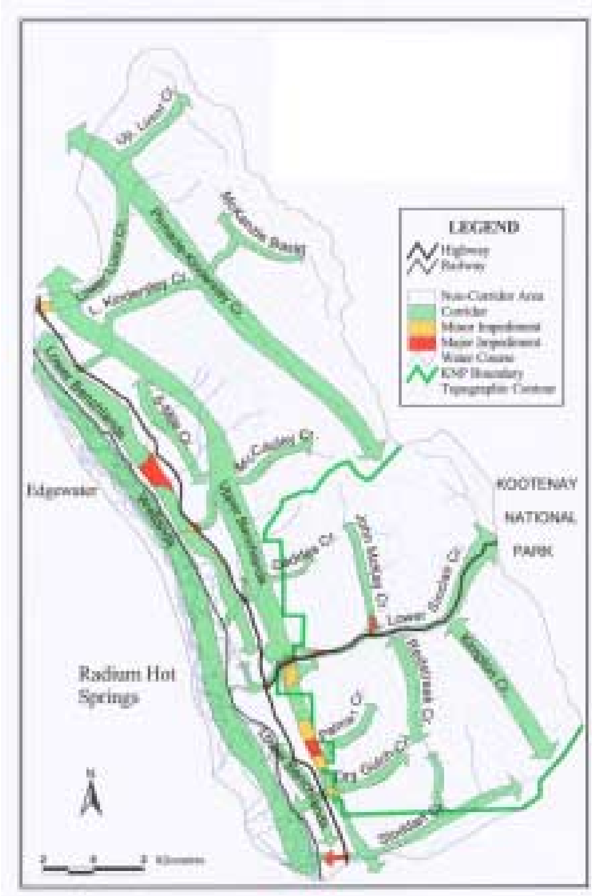

Fig. 8. Potential corridors for elk and grizzly bear, Radium Hot Springs area, B.C. Major impediments to movement, such as highways and permanent residential areas, are represented in red. Areas depicted in yellow represent minor to moderate impediments, such as golf courses and campgrounds.

Fig. 9. Potential corridors for bighorn sheep in the greater Radium Hot Springs area, B.C. Areas depicted in red represent areas of high mortality risk due to collisions with vehicles or trains.

While a number of corridors were identified as the result of this study, certain corridors stood out as being particularly important for ensuring connectivity on a regional scale, for multiple species. These are:

- Upper Luxor Creek Corridor: Provides the only low elevation, forested, relatively secure linkage between the Kootenay and Columbia drainages within the study area.
- Upper Benchlands Corridor: Offers a high quality corridor for movements along the Columbia Valley and, because of its width and gentle topography, is probably suitable for a wide variety of species. Of particular significance, this corridor provides a safe route for animals traveling between the Columbia Valley and Kootenay National Park via the Lower Sinclair Creek Corridor.
- Lower Sinclair Creek Corridor: Represents another important low-elevation forested linkage between the Columbia and Kootenay Valleys. This corridor is used extensively by bighorn sheep throughout the year. As well, radio-telemetry data confirm movements of elk and wolf through this corridor.

Discussion

The modeling exercise served two primary purposes: (1) to reveal the location of potential movement corridors and (2) to elucidate hypotheses regarding the factors that affect the movements of animals. Another useful outcome of the modeling exercise was the identification of gaps in the existing ecological database for the Radium Hot Springs area. Modeling must be viewed as an iterative process in which the first iteration serves to elucidate assumptions and identify information gaps. Subsequent iterations serve to enhance the predictive ability of the model as assumptions are validated and better information is generated and incorporated into the model. The present analysis represents only the first, yet essential, step of this iterative process. Another advantage of a modeling vs. empirical approach to corridor identification is that the former tells the researcher something about where the animals *should be* moving rather than simply where they *are* moving. For example, wildlife may be avoiding optimal corridors because of human-related impediments.

The modeling approach to corridor identification also has its limitations, however. For one, it is based on an incomplete understanding of the factors that affect the movements of wildlife. Indeed, very little information was found in the literature describing the factors driving the choice of travel lanes by wildlife. Additionally, perhaps one of the most important limitations of using a spatial modeling approach for identifying corridors stems from its inability to adequately account for non-spatial factors such as predator-prey relationships, learned behaviours passed on from generation to generation, behavioural differences amongst individuals, knowledge of the landscape or motivation to reach a particular destination. It is easy to conceive how some or all of these factors could affect the choice of travel lanes and yet they are not readily accounted for in a spatial model. Other limitations of a modeling approach have to do not so much with the nature of the models themselves but with the quality of the data used as input.

Conclusions

Wildlife Corridors in the Radium Hot Springs Area

- The proximity of the Radium area to Kootenay National Park is very significant in terms of connectivity. There is general agreement among scientists that core protected areas, such as national parks, must not become "islands in a sea of development". Healthy wildlife populations require exchange of animals to ensure genetic variability. Connectivity also ensures protection against local extinction.
- A multi-jurisdictional approach to the preservation of a functional network of corridors is essential since, typically, wildlife movements do not respect political or jurisdictional boundaries.
- Although this study brings us closer to understanding how different elements of the landscape can affect the movements of wildlife, it represents only the first of several steps in an iterative process geared toward a more sophisticated understanding of wildlife corridors in the Radium area.
- This understanding is largely dependent on the collection of empirical data on wildlife movements in the area. At this time, such information is clearly lacking.

Connectivity for Elk

- Corridors derived from the elk model are probably suitable for a range of species as elk have relatively large home ranges, tend to use a variety of habitats throughout the landscape and can be sensitive to human presence.

- Attributes that appear to be important for elk corridors are:
  - Suitable habitat
  - Presence of ecotone between forested and open areas (edge)
  - Relatively gentle slopes
  - Presence of visual cover
  - Low levels of human disturbance
- The upper benchlands, because they contain most of the above characteristics, likely serve as a major conduit, of regional significance, for movements parallel to the long-axis of the Columbia Valley.
- Riparian corridors are believed to represent important travel routes for the seasonal movements of elk along the elevational gradient.
- While elk use of the wetlands is well recognized, their use by elk as a movement corridor is not well understood and would require further investigation.
- Sensory disturbance, associated with transportation corridors, human settlements as well as recreational facilities and activities, potentially represents a significant impediment to the movements of elk.
- Highway 95, and its associated high traffic levels and infills, is believed to represent a significant physical impediment to movement along major riparian corridors linking the Brisco and Stanford ranges to the Columbia River wetlands.
- Strip development, such as that present along Highway 95 south of Radium, is believed to increase the psychological barrier effect of the road.
- Within Kootenay National Park, a long-standing policy of fire suppression has resulted in a homogeneous, closed-canopy forest. Greater heterogeneity in the forest cover would likely increase habitat quality and connectivity for elk.

Connectivity for Bighorn Sheep

- Because bighorn sheep have such specific habitat requirements, it is believed that corridors derived from the sheep model are species-specific and thus, not suitable for a wide range of species.
- Generally speaking, movement corridors for sheep appear to be tied to the presence of escape terrain and high visibility. However, some evidence suggests that sheep will, when required, cross areas of insecure habitat in their movements.
- Sheep appear to make extensive use of the Lower Sinclair Creek Corridor for movements between summer and winter ranges.
- Bighorn sheep appear to habituate readily to human presence, especially in predictable situations. However, the behavioural and physiological responses of sheep to humans and roads have not been formally tested in the Radium area. Sheep may be experiencing long-term stress as a result of their close proximity to humans even if the signs of stress are not overt.
- Collisions with vehicles along Highways 93 and 95 are the primary cause of mortality in the Radium herd.

Connectivity for Grizzly Bear

- Grizzly bears are generally considered an excellent umbrella species and as such, corridors that are functional for this species are likely suitable for a range of species.
- Human use along roads and trails represent a major threat to connectivity for grizzly bear in the Radium area.
- Highway 93 likely impedes grizzly bear movements between the Brisco and Stanford Ranges. The extent of the impediment, however, is not known.
- Grizzly bear use within the Columbia Valley appears to be minimal, although the upper benchlands may be important for grizzly bears in terms of providing a safe route connecting one side drainage to another.
- Optimally, grizzly bear corridors should:
  - Have low levels of human disturbance
  - Provide visual cover, especially in proximity to roads
  - Be energetically efficient
  - Provide some food sources
- Within Kootenay National Park, a long-standing policy of fire suppression has resulted in a homogeneous, closed-canopy forest. Greater heterogeneity in the forest cover would likely increase habitat quality and connectivity for grizzly bear.

Recommendations

General Recommendations

The study led to the formulation of four general recommendations aimed at preserving or restoring habitat connectivity in the Radium Hot Springs area. These are briefly described below.

Formation of a Sub-Regional Ecosystem Advisory Committee

I recommend the formation of an ecosystem advisory committee whose mandate would be to develop a conservation strategy for the greater Radium area. Such a committee should be composed of representatives of all agencies responsible for land management in the area, such as the Village of Radium, the Regional District of East Kootenay and Kootenay National Park. One of the most pressing tasks to be undertaken would be the development of guidelines aimed at preserving a functional network of corridors. To protect important wildlife corridors, it is imperative that this be completed as soon as possible, before any new development projects are allowed to proceed.

Formation of a Sustainable Economy Committee

Long-term ecological conservation cannot be achieved without a concerted effort to develop a sustainable economy for the greater Radium area. Such an economy is one built on entrepreneurial activities that do not impair ecological processes. It is often overlooked that efforts to preserve wildlife in the Radium area will pay long-term dividends to local residents in terms of both ecological and economic prosperity. One of the first primary tasks of the proposed committee would be to develop a vision for the greater Radium area along with clear objectives for the achievement of a sustainable economy. Elucidation of such a vision and objectives should involve extensive public participation.

Establishment of an Inter-Jurisdictional Wildlife Database

A central library housing electronic and paper copies of all ecological work completed within the greater Radium area would be tremendously beneficial in fostering an ecosystem approach to wildlife management. In addition, a website allowing documents to be accessed on-line could be an effective means of making ecological information available to researchers, decision-makers and the general public. A readily accessible GIS database would also be invaluable in facilitating multi-jurisdictional wildlife research.

Monitoring of Wildlife Movements

While this project was useful in identifying potential wildlife corridors in the Radium area, monitoring of these corridors is the essential next step for determining the extent and nature of their use by various species. Of highest priority are those corridors likely to be affected by future development projects. Monitoring is a critical element of ecological land-use planning as it is the cornerstone of an adaptive management strategy.

Specific Recommendations

In addition to these general recommendations, I presented more specific recommendations for each of the focal species as well as for each potential corridor identified. These recommendations were tailored to specific stakeholders and took into account existing legislative and policy frameworks. Recommendations for future research and management activities were also provided.

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