Outdoor Recreation Council of BC

# TRAIL DEVELOPMENT GUIDELINES TO MINIMIZE DISTURBANCE TO AND CONFLICT WITH LARGE CARNIVORES

PUBLICATION FOR OUTDOOR RECREATION COUNCIL OF BC

# ABOUT THE AUTHORS

## MAGI SCALLION, B.COMM, MBA, IAP2, MCELHANNEY

Magi is an experienced and passionate outdoor recreation professional. With more than two decades of experience with recreation management and trail planning under her belt, Magi believes that great trails start with great planning. She has supported numerous trail development guidelines in Western Canada and is excited to compile this document to give much needed guidance on how to plan and design trails to minimize disturbance to wildlife.

## KIM TITCHENER, B.ED., B.A., B.ORPT, BEAR SAFETY & MORE INC.


Bear Safety & More's founder, Kim Titchener, has worked on wildlife conflict reduction programs with multiple government agencies, communities, and industries for 18 years. With increasing pressures on business, industry, and government agencies working in bear country to upgrade bear and wildlife management and training programs, Kim has expanded her focus to include a greater spread of sectors and industries in Canada and the U.S. She specializes in training staff, creating bear safety protocols, and incorporating a customized team of scientists to consult on her client's initiatives.

## CONTRIBUTIONS AND ACKNOWLEDGMENTS

We would like to acknowledge the following individuals for contributing their time to inform these guidelines via input, consultation, and review:

Brianna Burley, M.Sc., Wildlife Biologist

Adam Hadley, PhD, Landscape Ecologist

Matt Hadley, B. Sc., Trail Specialist

Peggy Holroyd, MEDes, RPP, MCIP

Alex McDonald, BIT, Trail Technician

Ted Morton, M.Sc. (candidate), Trail Specialist

Sara Parsons, B.Sc., Animal Health

Louise Pedersen, M.Sc., Outdoor Recreation Council of BC

Peter Thompson, PhD., Wildlife Biologist

Bear Safety & more Inc

McElhanney

# INTRODUCTION

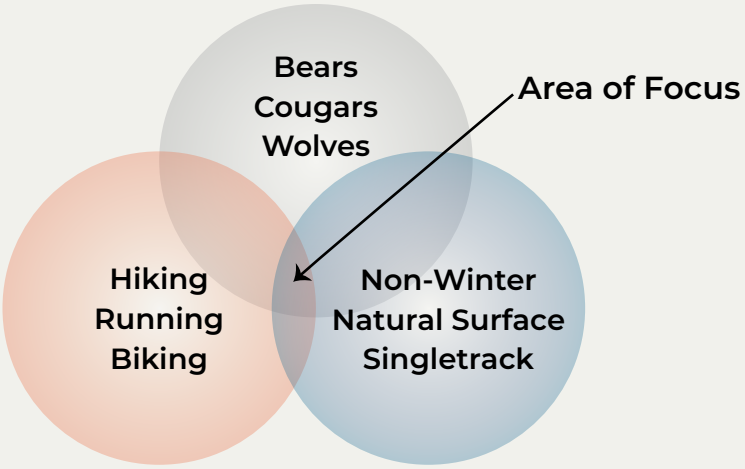
Trails are the connection between humanity and the natural world. These ribbons of recreation take humans from their everyday life into forests and natural areas for a variety of experiences. Whether purposefully designed or beaten in by use, trails place humans in the homes of wild animals.

Outdoor recreation provides many benefits for human health, the economy, and tourism. There is increasing research and concern about how humans impact wild spaces and the animals that live there, even with activities such as walking or hiking. Over the past 20+ years, extensive research has been undertaken to understand the impacts of humans on wildlife movement and behaviours. Not to mention, every time a human is hurt or killed by a wild animal the focus intensifies, and questions are raised on how to minimize and avoid these unfortunate events.

The idea for these guidelines came from the volume of research available and currently underway on the impacts of recreation on wildlife. This is a fairly wide-ranging area of study and the distillation of this research into a concise and usable format by trail developers is largely missing. These guidelines are intended to provide some suggestions and best practices for trail developers to plan, develop and manage trail systems in such a way that potential disturbance and resulting conflicts with large carnivores are minimized, enhancing trail user safety.

**As populations increase and recreation becomes more popular and accessible, wildlife disturbance increases and human-wildlife interactions become more prevalent.**

**Mindful recreation development is ever more important.**




## GUIDELINE FOCUS

To synthesize the volume of human/wildlife research available and present a manageable document, these guidelines have a specific focus on non-motorized (hiking, trail running, and mountain biking) recreational use of non-winter trails. The guidelines are informed by research on bears (black and grizzly), cougars (and other large cats), and wolves , in particular, because of the research available on these species.

## THE TRAILS

Single track, natural surface, non-motorized, non-winter recreational trails are the focus of these guidelines. These trails are the most prolific within the environments favoured by bears, cougars, and wolves in British Columbia. These narrow trails are often constructed by volunteer organizations who have few resources to do extensive environmental review or get recommendations from wildlife specialists. Further, the nature of narrow, natural surface trails often lends itself to surprise or unplanned encounters with wild animals.

The intent of these guidelines is to make all trails safer and more sympathetic to the needs of wild animals by educating trail developers on the best practices associated with the majority of trails in the province. Roads and paved pathways are outside of the context of these guidelines.

## THE ANIMALS

Known as apex predators, carnivorous mammals, and large predators, there is a certain mystique around the bears, cats, and wolves found in BC's forests. Not only are these animals the subject of legends, but they're also the most likely to attack and kill humans in defensive or predatory situations. Ungulates are also capable of defensive attacks that harm or kill humans and their pets, but these interactions tend to be less common, less likely to cause fatal injury, and less sensationalized by the media.

Bears (both black and grizzly), cougars (and other large cats), and wolves exhibit similar patterns of behavior when exposed to human recreational use. Generally, their desire is to avoid interaction with humans. When pressured, these animals may act unpredictably to defend their territory, food source, and family units.

Research on coyotes does not inform these guidelines, as they have distinctly different behaviors around humans that are often contrary to the other large carnivores in these guidelines. Further, coyotes have been shown to adapt to human presence well and often live in or near high human population density areas. While coyotes do present a hazard and concern to trail users and consequently trail planners, additional research and study should be conducted on that species for constructing trails in areas where coyotes may be perceived to be a problem.

**The guidelines presented in this document are not suggested to be a substitute for an in-depth environmental study prior to trail design and construction.**

Seasonality, availability of food, and the presence of other animals (such as equestrians and dogs) may change the reaction and behavior of the large carnivores that are the focus of these guidelines; however, we believe that if these recommendations are followed, conflict and disturbance should be minimized for most uses of narrow, natural surface recreational trails.

## DOCUMENT ORGANIZATION

This document is broken into three sections, each relating to a different phase of trail development. In the first phase, we investigate best practices for the planning phase of trails. These recommendations can be applied as trails or trail systems are being planned. The second phase of trail development is design; the phase where the line is mapped and physically laid out and constructed on the landscape. Finally, the operations stage involves ongoing maintenance, monitoring, user management, and research to ensure conflict and disturbance is minimized.


## LITERATURE REVIEW

A literature review accompanies these guidelines, providing information on the research that was reviewed and used to create these recommendations. The literature review is attached as an appendix.

# CONTENTS

## PLANNING



## DESIGN



## OPERATIONS

# PLANNING

Planning is the first phase of developing or upgrading a trail or trail system. The planning phase of trail development often entails choosing the conceptual location of the desired trail or trail system, developing the trail management objectives, and considering appropriate trail densities.

The diagram below illustrates a typical planning process. The trail and network concept will be refined and adjusted at each step of the process and may even need to be abandoned if there are significant, unforeseen hurdles.

## GUIDELINE 1: REVIEW LAND USE PLANS

It is a best practice to begin trail planning with landscape-level planning. Typically, landscape-level planning is led by governmental authorities with the support of environmental professionals and identifies areas on a large scale that are appropriate for recreation, development, and industry, among other purposes.

These land use plans may identify areas that are appropriate for higher trail densities or more concentrated use, as well as areas where recreation, types of recreation, or recreation events are limited.

### BEST PRACTICES:

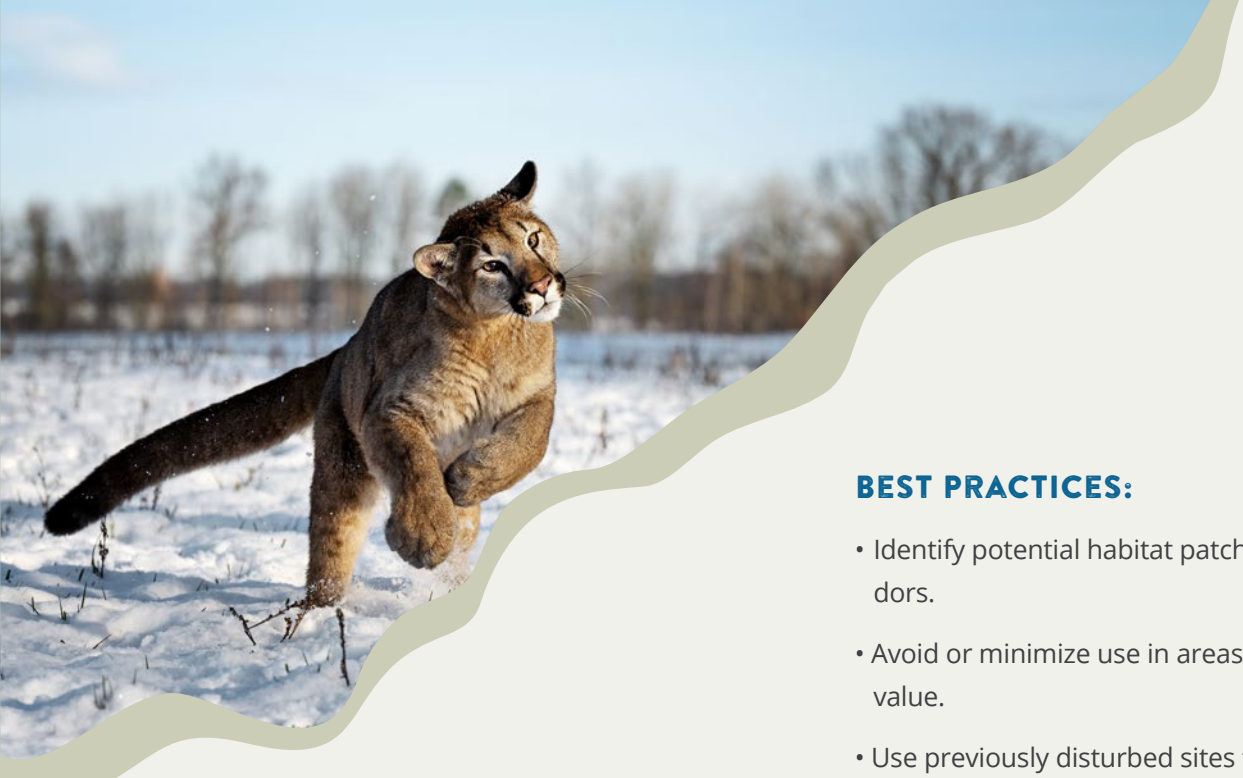
- Research and review landscape-level plans pertaining to recreation.
- In areas that are identified as appropriate for recreation, consider higher density trail systems with more accommodations for high volumes of use and special events.
- In areas that are identified for limited recreation due to ecological values, provide a lower density of trails, consider temporary or seasonal closures, and generally follow guidelines to limit volume of users and trails.
- In areas that are identified as important for conservation, consider eliminating or minimizing recreational trail use. Use planning, design, and operations best practices to discourage or remove recreation opportunities or attractions.

## GUIDELINE 2: UNDERTAKE ENVIRONMENTAL STUDY

As part of the trail planning process, an environmental review of some level should be completed to identify environmental values (including wildlife) of a particular area of land. This review may be conducted via desktop but may also include field study.

### BEST PRACTICES:

- If wildlife disturbance is anticipated, it is best practice to hire a Registered Professional Biologist who has experience in wildlife study to perform a desktop and/or field review. In BC the T.E.S.T tool, which was developed by the Shuswap Trail Alliance, can assist with determining high value habitat from a desktop perspective and is a great place to start.
- Long term studies are the most effective way to capture the full picture of wildlife habitat use and behaviour in an area. A professional biologist should be involved in directing the study. All animals may use or select different habitats at different times of the year. Budget appropriate time for the study which could take a year or more.
- Ask a professional to set up a simple, repeatable study that can be used to monitor wildlife prior to construction, during construction, and during operations. This will provide important information on the effectiveness of the trail design and management. This study may be the simple placement and collection of wildlife camera data, public reporting mechanisms for wildlife sighting, or a plot of land where tracks are monitored.



## GUIDELINE 3: AVOID HIGH VALUE WILDLIFE HABITAT

It is easier to identify habitat that is desirable for large carnivores than it may be to avoid it. Trails often become part of human habits over many years or are developed due to proximity to residential areas. Eliminating use or stopping the development of trails may be impossible, thus the next best option is to minimize use and trail density in high value areas.

The identification of wildlife corridors and habitat patches should be part of landscape-level planning by environmental specialists. Without the benefit of identified corridors and patches, trail planners may incorporate conceptual delineations of these features into their planning, using information from the environmental review.

### BEST PRACTICES:

- Identify potential habitat patches and wildlife corridors.
- Avoid or minimize use in areas of high wildlife value.
- Use previously disturbed sites for portions (or all) of the trail, to limit the impact on vegetation and habitat.
- Avoid placing trails in habitat patches.
- Minimize trails in wildlife corridors. Where trails are necessary, situate trails perpendicular to animal travel and cross the corridor in the least distance possible.
- Use the T.E.S.T. tool to work through the process of identifying important wildlife habitat areas.
- Review information available through the BC Conservation Data Centre (CDC) database that provides information on over 22,000 plants, animals, and ecological communities in BC.
- The BC Species and Ecosystems Explorer is also a helpful tool. Draw a polygon on their online mapping tool to identify ecological features of interest within a specified area.

**HABITAT PATCH**

*An area of land typically consisting of high value habitat that is a minimum size, depending on the local or regional needs.*

**WILDLIFE CORRIDOR**

*A path of travel for wildlife between high value habitat patches. Recommended to be minimum 1.2km wide.*

| AREAS TO MINIMIZE TRAILS OR TRAIL USE | WHEN | WHY |
|---|---|---|
| Riparian areas | All seasons | • Wildlife corridors; source of food and water. |
| Valley bottoms | Non-winter months | • Fertile environment provides food and forage opportunities, also frequently close to bodies of water for drinking.<br>• Ungulate habitat; draws carnivores during spring calving season.<br>• Travel corridors. |
| Rivers + lakes | All seasons | • Water, drinking, and cooling.<br>• Wolves typically den within 150m of a fresh water source.<br>• Especially avoid confluence areas, shallow areas, or areas that frequently have log jams. |
| Steep slopes near alpine | Winter | • Typically used as den sites for bears and/or daybeds for cougars. |
| Cliffs, esp. south facing | Winter | • Typically, good habitat for cougars in winter months and used as den or daybed sites. |
| Avalanche paths | All seasons | • Spring source of carrion for bears and wolves, summer source of berries and other food for bears. |
| Alpine, sub-alpine, and montane meadows | Summer | • Food source for bears – glacier lilies, ground squirrels, marmots. |
| Dens, daybeds, or homesites | Winter, spring, early summer | • Wolves: low elevation, old growth forests near fresh water.<br>• Bears: steep slopes near the alpine.<br>• Cougars: steep slopes near the alpine. |

| CONSIDER | WHEN | WHY |
|---|---|---|
| Moraine features | All seasons | • Difficult travel for animals, devoid of sustenance.<br>• Trails that run along the "ridge" of the moraine may provide views, and the rocky terrain will have appropriate drainage. |
| Steep slopes (forested) | Non-winter | • Difficult travel, limited food sources.<br>• Trails in this location may provide views in sparse forests, and reasonable cross slope for more difficult or steeper trails. |
| Cliffs | Non-winter | • Difficult travel, no thoroughfare opportunities, movement barrier.<br>• The top of cliff features provides views and are often good destinations for rest nodes or trail terminus. |
| Deep drainages, ravines | Non-winter | • Difficult travel, terrain traps, movement barrier.<br>• Provision of bridges or crossing structures in these locations provides a point of interest in the trail system while minimizing trail placement in areas of high wildlife use. |
| Alpine | Late summer, autumn | • Fewer food sources attracting bears.<br>• After the alpine flowers have passed, the alpine is less attractive to bears, but may remain a pleasant place to recreate with expansive views and the colour of larch trees in the autumn. |

## GUIDELINE 4: DEMAND MANAGEMENT

Alongside the identification of habitat patches and wildlife corridors, the carrying capacity of an environment may impact trail density and user management. Collectively, the pairing of ecological carrying capacity and user management is referred to as demand management. Demand management refers to controlling human use of an area, as well as understanding the availability of underlying ecological resources and demands of other consumers, such as humans, in the ecosystem.

Consumers of ecosystem resources include the plants and animals the system supports, as well as tertiary consumers, like humans, that may inhibit the ability of animals to access the resources. In this sense, a narrow, natural surface trail may not cause stress to the ecosystem, but the human use of the trail is a disruptor. Bears will actively avoid trails which see more than 18 people per day, and high intensity use is considered to be 100 parties per month.[1]

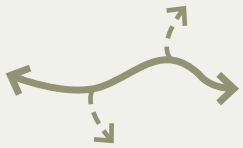
The zone of influence of human use on trails ranges from 50m to 200m, meaning that animals may be disturbed up to 200m from the trail. The zone of influence can vary depending on sensory barriers, such as dense vegetation, which provides cover and reduces noise disturbance for animals.

1 MacHutchon 2016

### BEST PRACTICES:

- Site trailheads, popular trails, and areas of intense use away from high value habitat patches and corridors.
- If trails must be sited in areas of high wildlife value either:
  - » Ensure trails are at least 400m apart to allow wildlife ample space to remain undisturbed between traffic on each trail, or
  - » Group trails in linear bunches with limited space between, and space the bunched trails by 400m or more.
- Plan for the evolution of the trail: identify anticipated peak and desired maximum volumes of use for trails and plan for how it will be monitored and evaluated.
- Consider how trail use volume can be managed by:
  - » Phased addition of new trails
  - » Directional looped trails
  - » Closures – seasonal, temporary, permanent
  - » Access limits via parking area size or public transit
  - » Trail use day passes and/or fee for use.
- Sketch up a trail system plan overlaid with ecological values; consider different trail system designs, such as linear systems with rest nodes instead of the traditional stacked loop. The linear system can reduce the trail density and gathering points.

*Linear System:*



**CARRYING CAPACITY (WILDLIFE)**

***The carrying capacity of an environment is the maximum population size of a biological species that can be sustained by that specific environment, given the food, habitat, water and other resources available. (Prato, 2001)***

**DEMAND MANAGEMENT**

***An approach to the allocation of scarce resources that is based on minimizing wastage, restricting supply and educating people to use less of the resource and use it more carefully. (www.OxfordReference.com)***

## GUIDELINE 5: DEFINE ACTIVITY TYPES AND INTENDED USE

Trails should be developed with a purpose. Defining things such as predicted use types, desired user experiences and even the trail surface characteristics that will deliver the experience is done in a written document called a trail management objective. These provide a description of the trail's purpose and the intended user experience– from providing mountain bike skill progression, to creating a thoroughfare to a lookout, or accessing a climbing crag. Trails may also be key transportation corridors or have historical or traditional uses by indigenous communities. The management objectives should align with the environmental features and constraints, and thus are a good way to ensure that trails are constructed appropriately in the environment.

### BEST PRACTICES:

- Define the intended trail uses, seasonality of use, and activity types to minimize environmental impact. Use trail design and operations principles to cement these intentions.
- Limit number of permitted trail activity types where lower volumes of users are desired.
- Restrict dogs: either require them to be on-leash or in control at all times, or prohibit them.
- Trails that will be used at higher speeds should be situated in areas with good sightlines.
- Trails for skill progression that will see repetitive use should be placed away from areas of high habitat value, habitat features (like dens or daybeds), or animal use.
- Trails designed for summer use that may be used in the winter season should avoid steep sub-alpine slopes where bears have dens and cougars have daybeds. If avoidance is not possible, enact seasonal closures.

# DESIGN

Trail design is the act of conceptually and physically "drawing the trail." This process typically starts with setting up a Geographical Information System (GIS) that can provide information about the topography and vegetation throughout the landscape as identified by aerial or satellite-based sensing to define a fairly accurate routing. Following the conceptual desktop design of the trail, the design team hits the ground with flags and physically lays out the trail corridor in the natural environment.

While planning is typically done as a desktop exercise, trail design often involves significant time in the field. During this process, more environmental features that impact trail alignments become readily apparent. Trail planning identifies the macro area for trail development and acceptable uses, while trail design will identify the exact corridor and detailed features to minimize disturbance and conflict.

## GUIDELINE 1: AVOID DESIGNING AND BUILDING TRAILS IN AREAS OF HIGH WILDLIFE VALUE

While planning will identify broad areas to avoid or use, the design process will identify specific areas of concern. Things like large berry bush patches, toes of avalanche paths, or smaller creeks and streams will present on the micro level of trail design.

### BEST PRACTICES:

- Never use game trails as the base for a trail corridor. These are established wildlife corridors and should only be crossed perpendicular, with linear density minimized (i.e. ideally stay at least 50m away when travelling parallel)
- Avoid or minimize trail segments near prime animal attractants such as berry patches or water sources.
- Avoid approaching rivers or streams where log jams or sand bars collect salmon, as these are popular areas for bears and wolves to hunt and scavenge.
- Cross riparian areas and watercourses perpendicularly, using the shortest path through and out of the riparian area.

## GUIDELINE 2: AREAS THAT HAVE LOW HABITAT VALUE MAY PROVIDE DESIRABLE FEATURES FOR TRAILS

Areas that are not typically attractive for wildlife may provide unique and special trail opportunities. These include:

- Moraines and rocky alpine areas do not provide food or security for wildlife and sustainable trail development in this environment could provide rewarding views or challenges for trail users. Access to these environments may be challenging as areas of high value habitat often create a barrier to the more remote and less hospitable areas.
- Open forests with limited undergrowth, such as poplar, aspen, or pine provide good sightlines for trails that have faster travel (such as descent trails or trails popular for trail running).
- Cliffs, ravines, or other natural barriers provide beautiful viewpoints or interesting features and are also typically avoided by animals looking to travel from point to point. These locations do have some safety and human management considerations that should be addressed with trail design, such as setbacks for slope stability and user safety, and avoidance of highspeed turns near a precipice.

***Note:*** these guidelines were written with large carnivores in mind. Some areas of low value to bears, wolves, and cougars may have high value to other ecological values, including other mammals or plants.

## GUIDELINE 3: APPLY METHODS TO REDUCE TRAIL SPEED

Where sightlines for both wildlife and trail users are limited, speed of travel on the trail must also be reduced to avoid a surprise encounter. This is particularly important during the fall when bears are focused on feeding and may take longer than usual to notice and respond to a disturbance in the environment. To slow speeds in areas of undergrowth, tight corners, or blind hill crests:

- Reduce turn radii.
- Leave frequent, mature trees to create chicanes and slalom effects to the trail, yet clear the branches and shrubs back to extend the sight lines. Leave deadfall to block shortcuts.
- Create or allow for more or larger protrusions on the trail surface, such as rocks, roots, or other features.

- Install Technical Trail Features (TTFs) designed to be taken at a lower speed on mountain bike trails.
- Place junctions or rest nodes where groups can stop to gather or wait in areas with good sight-lines and out of high-value wildlife habitat.
- When approaching blind hill crests or ridges, find and use the associated uphill to allow gravity to naturally slow trail users.

## GUIDELINE 4: ADJUST TRAILS TO SUIT HABITAT

It will be impossible to completely eliminate recreational trails from high value wildlife habitat, especially where trails are already established and popular. Trail design to suit the habitat combined with operational management (next section) is a proactive step towards addressing and mitigating potential disturbances and conflict.

### BEST PRACTICES:

- Trails that cross wildlife corridors should be made as short as possible and run perpendicular to the direction of wildlife travel (while still maintaining sustainable trail design principles). Good sight-lines should be accommodated throughout.
  - » Speed of travel should be as low as possible. Use trail design and construction techniques to achieve lower speeds, with the exception of tools like rest nodes and junctions which stop users completely.
  - » Trails should be relatively direct (to be short) but not straight, as straight trails have higher speeds of travel.
- Where more than one trail crosses a corridor, they should be more than 1.2km apart. If two trails are required in a small area, the trails should be grouped within 10-20m and a larger buffer provided on either side. An example of two trails that may need to be paired would be a climbing trail and descending trail to accommodate high user volumes.

## GUIDELINE 5: PLAN CONSTRUCTION FOR SEASONS AND TIMES OF DAY WITH LESS DISTURBANCE

Winter and spring are times of elevated stress and energy expenditure for animals, as food and habitat resources are limited.

### BEST PRACTICES:

- Plan trail construction for summer and fall seasons.
- Do not construct between dusk and dawn.
- Plan removal of attractants prior to construction. Consider removal of berry bushes prior to fruition.

## GUIDELINE 6: DESIGN TRAILSIDE AMENITIES TO MANAGE USE VOLUMES

As populations grow and recreation becomes more popular and accessible, it is important to design trail amenities to manage use volumes, where desired and appropriate.

- Build smaller parking areas or require shared transit for trail access points.
- Use filters or higher difficulty sections at the start of a trail to reduce use to more skilled visitors, where appropriate.
- Provide fewer trailside comfort amenities, such as benches or outhouses.
- Make trails narrower to prevent side-by-side walking and larger group sizes.
- Limit the recreational activity types that are permitted on the trail.

# OPERATIONS

Once a trail is constructed, the management and maintenance of the trail will have an impact on how well wildlife disturbance and conflict is minimized. Trail operations include everything from regular maintenance to signage and visitor use management. These operations occur throughout the life of the trail and are typically managed by the group that was responsible for constructing or authorizing the trail.

Trail operations typically focus on managing users of the trail, rather than avoiding wildlife, with some exceptions.

## GUIDELINE 1: REMOVE VEGETATION AND WILDLIFE ATTRACTANTS FROM THE TRAIL CORRIDOR

Bears' primary food source in the summer and fall months is berries. Berry bushes typically grow in open areas, including adjacent to trails where sunlight can penetrate the forest canopy. Dense vegetation, including grasses, berry bushes, or small trees all limit sight lines and muffle sound, resulting in the potential for more surprise encounters. Additionally, cougars will stalk prey from bushes at ground level.

- Remove berry bushes and vegetation to 1.5 m from the edge of the trail tread, annually.
- When re-vegetating a disturbed area, such as an adjacent decommissioned trail or the sides of a new trail, use native species and not legumes that attract large carnivores.

## GUIDELINE 2: MANAGE WASTE

Bears and wolves are attracted to human food, garbage, and other waste.

- At front country locations with maintenance staff, provide bear-resistant garbage receptacles at trailheads and on-trail gathering points. Ensure the locking mechanisms are functioning properly at regular intervals. Empty the garbage and dispose of it at a proper facility regularly.
- Provide signage to educate trail users about "Leave No Trace" principles.
- Consider fines or penalties for littering, feeding wildlife, or other such activities.

## GUIDELINE 3: EDUCATION

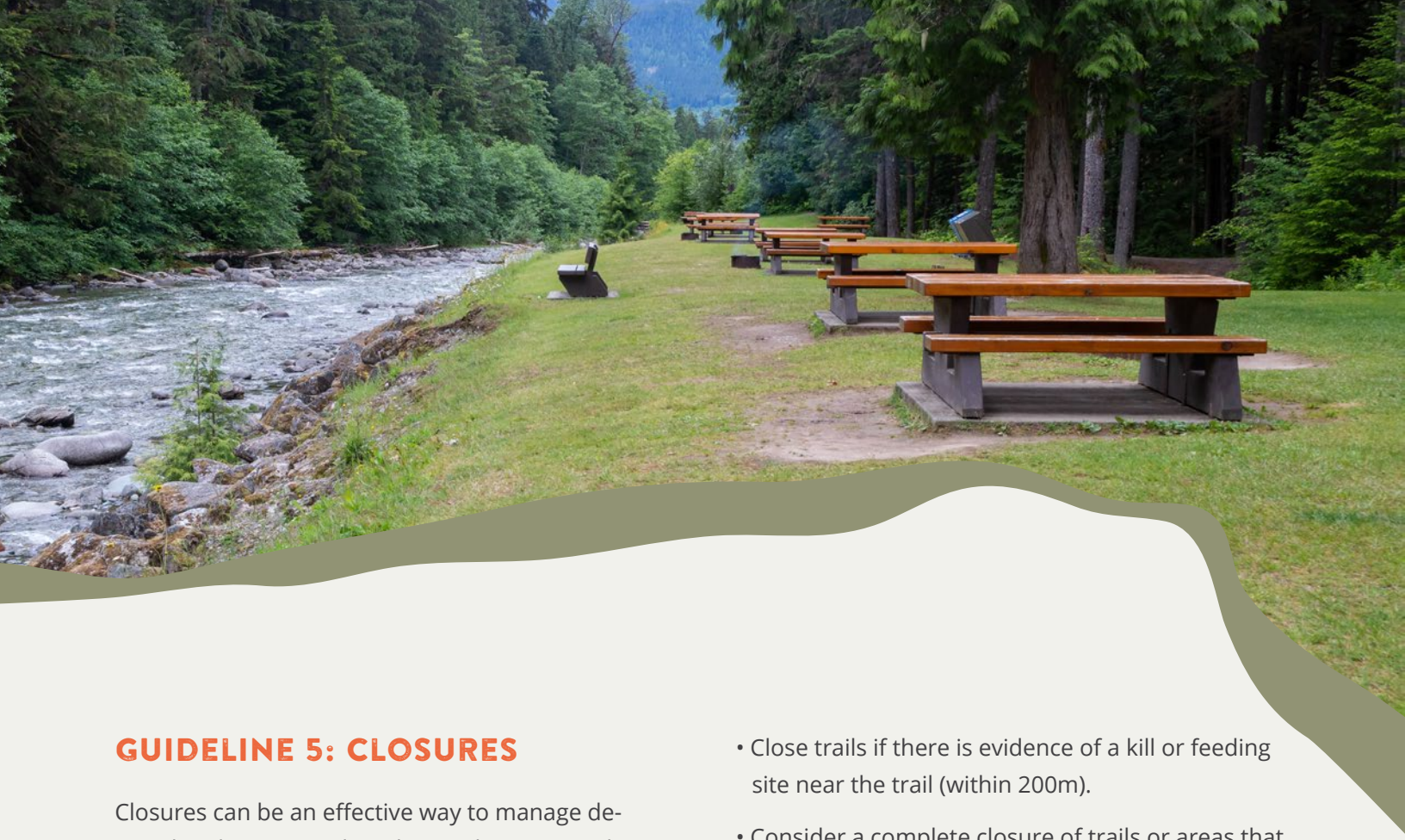
Similar to demand management techniques, education of users is critical to ensure the rules and measures of safe trail use are respected and effective.

- Encourage trail users to travel in groups of four.
- Provide appropriate signage at trailheads regarding wildlife in the area and how to minimize disturbance or conflict.
- Create opportunities for trail users to undertake additional training on how to recreate safely with wildlife.
- Give information on where users can acquire bear spray and receive training on how to use it properly.
- Teach trail users the importance of making noise to alert wildlife to their presence and appropriate noise-making techniques. Short, frequent yelling, followed by listening, is a better technique than a constant noise making source, such as music or a bear bell.
- Discourage trail users from littering, including leaving compostable items near trails, which decompose and become wildlife attractants.

## GUIDELINE 4: MANAGE DEMAND

Given the use thresholds and zones of influence for wildlife disturbance set out in the earlier sections, demand management is an important part of minimizing the damaging effects of recreation on wildlife and their habitats.

- Identify maximum use limits and manage use to those limits by providing or limiting access and amenities.
- Reduce the size of parking areas to reduce trail access and usage.
- Consider a permit or pass system to limit or manage use on a daily basis.
- Clearly identify permitted user types, including dogs. Off-leash domestic dogs have been shown to cause disturbance to nearly all wildlife.
- Reduce, make more rustic, or remove trail amenities, such as signage and benches, to decrease the comfort and attractiveness of the trail experience.



## GUIDELINE 5: CLOSURES

Closures can be an effective way to manage demand and minimize disturbance during critical times. Temporary closures may be applied to specific activities, specific times of day or year, or a combination.

- Close trails in prime habitat between dusk and dawn when animals are more active.
- Close trails during berry season where trails provide high value feeding opportunities and vegetation removal is not an option.
- Close trails to specific user groups (i.e. runners or mountain bikers) during times when there is more vegetation impeding sight lines.
- Close trails near den or daybed sites seasonally when animals are expected to emerge with their offspring.
- Close alpine trails in the specific summer periods when the meadows provide important feeding opportunities for bears. This may change annually based on snowpack or other factors.
- Close trails if there is evidence of a kill or feeding site near the trail (within 200m).
- Consider a complete closure of trails or areas that are in prime wildlife habitat, year-round, when temporary or seasonal closures are ineffective.
- Completely decommission resource roads that provide access to areas that are closed to recreation.
- Where possible, ensure closed trails are noted as such, or completely removed from navigational apps such as Trail Forks and All Trails.

Ensure that these closures are broadcast with reasoning, appropriate signage (showing the dates), and multiple communication techniques. It is important that closure signage be removed and the trails opened when the closure is passed. Leaving lingering closure notices often results in the community becoming de-sensitized to and eventually disobeying closures.

## CONCLUSION

These guidelines have been compiled from available research as outlined in the appended literature review. As titled, these guidelines are intended to provide guidance for trail developers to minimize disturbance to large carnivores. They may not be appropriate in every situation, and it may not be possible or feasible for a trail developer or group to undertake all of the recommendations in these guidelines. As trail developers become intentionally more conscious of the environment, recreational trail experiences will be made safer and more sustainable, which is the end goal.

# LITERATURE REVIEW

# Recommendations for Trail Building to Reduce Impacts to Large Carnivores and Minimize Human-Wildlife Conflict

**Parsons, S., Scallion, M., Titchener, K.**

**Edited by: Thompson, P.**

**March 2023**

**Abstract**

As the global population grows and human activities continue to expand into natural areas, the risk of human-wildlife conflict increases, and costs to wildlife are detrimental. Development of new trail systems provides a variety of benefits to humans, but has a largely negative impact on wildlife, particularly large carnivores. Trails used for non-motorized recreation reduce available habitat, fragment the landscape, and can spatially and temporally alter the behaviour of large carnivores. This review examines the impacts of non-motorized recreation and trail system development on large carnivores in North America, with a focus on British Columbia, Canada. Recommendations are provided for the planning, design, and maintenance phases of trail development to reduce impacts to wildlife and minimize the risk of human-wildlife conflict. Ultimately, the goal of this article is to promote sustainable and responsible trail building practices that support both human enjoyment and the long-term viability of large carnivore populations.

**Keywords:** recreation ecology, human-wildlife conflict, large carnivores, non-motorized recreation, trail system development

## Introduction

Wilderness areas in North America attract millions of visitors annually to experience pristine landscapes, natural features, and wildlife diversity (National Park Service, 2022a). Parks and wildlife reserves contribute to the tourism economy, provide health benefits to people, and can facilitate a greater

appreciation for nature and wildlife (MacHutchon, 2000; 2016; Miller *et al.,* 2020). Although intended as wildlife preservation areas, these spaces often attract high numbers of visitors who wish to use the landscape for recreation. These vast areas boast trail systems that allow people to participate in a variety of non-motorized activities, including hiking, mountain biking, and trail running. Over time, expansion and repeated use of trail networks can negatively impact some wildlife species, particularly large carnivores (Lucas, 2020; MacHutchon, 2016; Miller *et al.,* 2020). As the global population rises and more people recreate in nature, wildlife disturbances increase, and human-wildlife conflict becomes increasingly prevalent (Dickman, 2010; Lucas, 2020).

This review will examine previous research to uncover the impact trail expansion and usage has on large carnivore species. There will be a focus on the grizzly bear (*Ursus arctos*), black bear (*Ursus americanus)*, cougar (*Puma concolor)*, and grey wolf (*Canis lupus*). In addition, recommendations for planning, design, and maintenance phases of trail building will be provided. The guidelines will consider factors contributing to human-wildlife conflict, with intent to minimize such interactions and reduce the overall impact of trail systems to wildlife. This information could apply to various environments, but the intended focus area of this paper is British Columbia, Canada.

*Large Carnivores*

Large carnivores such as cougars, grizzly bears, black bears, and wolves play immense roles in stabilizing populations of various species through different trophic levels (Danell *et al.*, 2006). If either of these animals were removed from an ecosystem, herbivore populations would grow, leading to decreased vegetation and an unbalanced ecosystem (Danell *et al.*, 2006). In addition, large carnivores reduce disease transmission through predation and behavioural alteration of pathogen host species (Hofmeester *et al.,* 2017). There is also evidence that bears inadvertently protect fruit-bearing plants by dispersing seeds across the landscape via scat (Naoe *et al.*, 2016).

Despite their importance in maintaining healthy ecosystems, large carnivore populations have been at risk in the past and continue to be jeopardized in some areas of North America (Government of

Canada, 2022b). The government of Canada (2022b) stated that grizzly bears are considered a species of "special concern" throughout Canada. Grizzly bears are "threatened" in Alberta as a result of extirpation from the Canadian prairies and low population size in the Canadian Rocky Mountains (Government of Canada, 2022b). Grizzly bears in British Columbia (B.C.) are considered to be "at risk" with an estimated population of 16,000 and varying densities across the province (Environmental Reporting BC, 2020; Government of Canada, 2022b). Black bear populations are secure across North America, and many states and provinces allow hunting by permit only (Government of Canada, 2017a). Currently, grey wolf numbers in B.C are secure and growing, with an estimated 8,500 wolves in the province (BC Gov News, 2017). Cougar populations are continually increasing and expanding their range in Alberta (Government of Alberta, 2019a), and overall populations in Canada are "secure" (Government of Canada, 2017b).

*Threats to Large Carnivores*

Large carnivores can withstand harsh and unforgiving environments but are also extremely sensitive to human-induced changes in habitat and human presence (Government of Canada, 2022b; Miller *et al.,* 2020). Habitat loss and human-wildlife conflict are two major factors that contribute to population declines in many animal species in North America, including large carnivores (Dickman 2010; Miller *et al.,* 2020).

Large carnivores require vast, connected habitat ranges and travel far in search of food, mates, and denning sites (Miller *et al.,* 2020). Grizzly bears occupy home ranges that can be as large as 2,000 $km^2$, depending on the sex and location of the bear (Government of Canada, 2022b). Wolf home ranges are dependent on food availability and may be as large as 2,500 $km^2$ (Government of Canada, 2022a). Prime wildlife habitat has been divided and fragmented by roads, recreation areas, and urbanization (Miller *et al.,* 2020). Habitat fragmentation occurs when large habitat patches are divided into smaller areas, either through natural or anthropogenic processes (Miller *et al.*, 2020). In addition to decreasing the total amount of available habitat, fragmentation can also prevent animals from obtaining access to food or mates, and has contributed to a loss of genetic variability in some species (Lino *et al*., 2019; Miller *et al.,*

2020). Danell *et al.* (2006) suggested the majority of large carnivore habitat in northern temperate regions has been altered by humans, which has consequentially altered the spatiotemporal distributions of these species. The Bow Valley of Alberta, Canada, has seen extensive residential development in the last 20 years, which has encroached on optimal cougar habitat (Government of Alberta 2019a). As a result, prey have sought safety in developed areas, attracting cougars and other large carnivores to townsites, increasing the risk of human-wildlife interactions (Government of Alberta, 2019a).

National and Provincial Parks have a responsibility to protect and maintain rich habitat for wildlife, but are also tasked with catering to people who wish to recreate and experience nature (MacHutchon, 2016). As more people venture into wild spaces, exchanges between humans and wildlife increase, which not only disturbs wildlife, but leads to undesirable and dangerous human-wildlife interactions (MacHutchon, 2016). Constructing new trail systems displaces wildlife and reduces available habitat, and non-motorized recreation on trails can alter the behaviour and physiology of wildlife (Miller *et al.*, 2020). Human recreation can increase stress levels, and reduce growth, reproduction, and immune system function in wild animals (Lucas, 2020). Large carnivores will purposefully avoid areas with human activity, which pushes them into less optimal habitats for hunting and foraging, resulting in less energy available for growth and reproduction (MacHutchon, 2000).

It can be energetically advantageous for large carnivores to habituate to humans, as instead of expending energy on fleeing, they might continue hunting and foraging in the company of humans (MacHutchon, 2016). Unfortunately, habituated large carnivores are more likely to be involved in conflict with humans, and may be more attracted to anthropogenic food sources, which can lead to food-conditioning (Lucas, 2020). Food-conditioned animals show heightened levels of aggression toward humans, increasing the risk of people being injured; wildlife officers often must resort to destroying the animal (MacHutchon, 2016).

*Human-Wildlife Conflict*

Co-existence with large carnivores becomes increasingly difficult as the human population continues to expand and wildlife habitat is replaced with residential and recreation areas (Bombieri *et al*., 2023). Human-wildlife conflict can occur when humans and animals come into close proximity with each other, whether intentionally or during an accidental surprise encounter (MacHutchon, 2016). How an animal reacts to human presence is unpredictable and depends on the individual animal and their perceived level of threat (Government of Alberta, 2019b). Miller *et al.* (2020) states that quicker and more direct approaches toward animals typically results in a more pronounced response from that animal. A large carnivore may defend themselves if they feel threatened by humans, which can lead to serious injury or death for the people involved (Government of Alberta, 2019b). The upward trend in the number of human-wildlife conflict incidents in the last 20 years has resulted in many people and large carnivores being killed each year in North America (MacHutchon, 2016).

Reducing the risk of conflict is essential to the conservation of large carnivore populations and human safety (Bombieri *et al*., 2023). Data of large carnivore attacks in Canada from 2000-2015 showed black bears (105 attacks) were recorded attacking humans most frequently, followed by grizzly bears (70 attacks), cougars (29 attacks), and wolves (5 attacks; Bombieri *et al.,* 2023). Wildlife attacks in North America are often the result of risk-enhancing behaviours, which Bombieri *et al*. (2023) described as feeding large carnivores, recreating alone, walking an unleashed dog, moving silently, and leaving children unattended. Most grizzly bear attacks are thought to occur as the result of sudden encounters (Herrero et al., 1986). Factors that influence the risk of sudden encounters include time of year, behaviour of recreationists, the animal's past experience with humans, sightlines, proximity to running water or dense cover, and type of habitat the trail is in (Herrero *et al*., 1986). If large carnivores have access to human food and garbage, they may be more likely to seek out humans as prey as they become more tolerant of them (Hererro *et al*., 1986). Although some of the factors contributing to human-wildlife conflict are behavioural, there are some measures trail developers can use to reduce the risk of interactions between people and wildlife which will be discussed further in this paper.

*The Landscape*

Western Canada is known for its diversity of ecosystems, but for the purpose of this paper we will focus only on grassland, montane, sub-alpine, and alpine zones. Each of these areas consist of unique terrain, vegetation, and wildlife.

Grasslands dominate the Canadian provinces of Alberta, Saskatchewan, and Manitoba, as well as throughout central United States, stretching south into Mexico (Anderson, 2006). Grasslands are mostly planar landscapes with occasional hills and sloping ravines (Anderson, 2006). These plains are teeming with various grasses, but mostly lack trees, bushes, and shrubs (Anderson, 2006). Populations of cougar, black bear, and grey wolf can be found in dwindling numbers on the prairies of North America (Laliberte & Ripple, 2004). As previously mentioned, grizzly bears have been extirpated from the prairie ecosystem (Government of Canada, 2022b).

Montane zones are the transition area from rolling foothills to the sub-alpine and is North America's most diverse environment (Willoughby *et. al,* 2021). In Canada, British Columbia is home to approximately 90% of the montane zone, and Alberta contains the other 10% (Scudder & Smith, 2011). The landscape varies from dense coniferous forest to riparian woodland areas with valleys, lakes, and rivers scattered throughout (Scudder & Smith, 2011). This ecozone has a greater species diversity than any other zone in Canada, and is an excellent place for the cougar, grizzly bear, black bear, and wolf to reside (Scudder & Smith, 2011).

Subalpine areas are located just below the upper tree line on mountains covered in thick forests, with secluded lakes and open wildflower meadows (National Park Service, 2022b). The subalpine zone is home to a diverse community of plant and animal species, though becoming sparse as elevation increases (Martin, 2001). This is prime habitat for the four large carnivores we are focusing on in this review (Martin, 2001; National Park Service, 2022b).

Alpine zones are jagged and rocky areas above tree line in mountainous environments, containing minimal vegetation due to unfavorable climates (Martin, 2001). These high-elevation areas are exposed to strong winds, extreme temperatures, excessive sun exposure, and lengthened snow cover (Martin, 2001).

Few plant species can survive in the alpine zone, aside from small shrubs, grasses, and sedge plant species (Martin, 2001). Large carnivores occasionally hunt in alpine areas despite the region's low productivity, particularly in areas where human influence decreases the suitability of low-elevation habitats. (Martin, 2001).

**Factors to Consider for Trail Building Phases**

It is of utmost importance to preserve large carnivore populations in order to maintain harmony and equilibrium in North America's sensitive ecosystems (Danell *et al.*, 2006). Human development and presence in wilderness areas have many positive effects for humans, but negative consequences for wildlife (Miller *et al.*, 2020). During trail system development, builders should consider factors in the planning, design, and maintenance phases of construction to have the lowest overall impact on wildlife. In addition, trail designers must be aware of the trail features and types of recreation that might increase human-wildlife conflict (MacHutchon, 2016; Miller *et al*., 2020).

Planning Phase

In the early stages of trail development, the first step is choosing a general location for the trail system to be sited. In choosing a location, there are important considerations to reduce impact on wildlife, such as type of habitat, demand management, and intended use of the trail.

*Type of Habitat*

Optimal habitat for large carnivores includes mature and old-growth coniferous forests, riparian areas, valley bottoms, wetlands, and areas near rivers and lakes (MacHutchon, 2016). Large carnivores will travel long distances to access food sources and mates, and tend to use the path of least resistance (MacHutchon, 2000). Natural features such as cliffs, moraines, narrow terrain, and steep slopes act as barriers and impede a large carnivore's movement (MacHutchon, 2000). Wildlife corridors are implemented to connect land patches and allow wildlife to move freely and away from human influence

(Bow Corridor Ecosystem Advisory Group, 2012). When trails are built in areas where habitat quality is high and wildlife corridors have not been established, habitat fragmentation occurs, which prevents animals from accessing high quality food and can lead to low genetic diversity within a population (Lino *et al*., 2019). Narrow and unpaved recreational trails do not typically reduce functional habitat connectivity for larger mammals unless the trails are frequently used by humans (Miller *et al*., 2020).

MacHutchon (2000) recommends that low-quality wildlife habitat be used when choosing a location for trail development. They also suggest establishing wildlife corridors that animals can use to safely travel between habitat patches, as this will reduce impacts on wildlife and avoid unwanted interactions with humans (MacHutchon 2000; 2016). Habitat patches are connected by wildlife corridors and should meet the food, security, and water requirements of animals for short periods of time, while absent of human disruption (BCEAG, 2012). Within habitat corridors, trails may be permitted, but should be perpendicular to the corridor and grouped together with other crossings to minimize the number of disturbances within the corridor (BCEAG, 2012).

Building trails within a 1.6 km radius of a wolf den or homesite can displace wolves and reduce reproduction rates (MacHutchon, 2016). Wolves will sometimes use the same dens for several consecutive years, whereas some will choose a new den each year, or use multiple dens in a single year (Paquet & Carbyn, 2003). If there are known den sites with yearly use, seasonal closures should be implemented, especially when the den is occupied which is generally between April 15 and July 15 (MacHutchon, 2016). The majority of wolf den sites in coastal British Columbia were located in old-growth forests at low elevations, typically within 150m from a fresh water source (MacHutchon, 2016). Areas with these characteristics are important to avoid when siting a location for a new trail system.

Cougars spend a lot of time in riparian areas and coniferous forest where they can find prey such as bighorn sheep, elk, and deer (Blake & Gese, 2016; Bischoff-Mattson, 2019). Cougars tend to hunt in areas with rugged terrain, steep slopes, and vegetative cover that will allow them to ambush their prey (Bischoff-Mattson, 2019). During winter months, cougars mainly hunt at lower elevations and on southern aspects, as their preferred prey species move there to avoid deep snow (Blake & Gese, 2016).

The Washington Department of Fish and Wildlife (WDFW; n.d.) stated that cougars spend time resting and raising their kittens in daybeds, preferably in forested areas with high concealment via thick vegetation, roots, and downed trees (Elbroch *et al*., 2015). Daybeds tend to be far from roads, and close to streams in rocky forests or riparian areas (Rieth, 2010). When choosing a location for trail system development, considering these habitat features could minimize cougar disturbance.

Black and grizzly bear denning habits vary based on latitude and climate. Black bears in British Columbia that live near the coast typically spend less time in the den than those that live further interior (Province of British Columbia, 2001). Most black and grizzly bears will enter the den anywhere from October to December, and emerge from March to May (Stevens & Gibeau, 2005). Black bears in Yellowstone chose to den on Northern aspects with a slope of 20°-40°, at an elevation range of 1,768m-2,621m (National Park Service, 2019). Yellowstone grizzly bears also preferred Northern aspects, but denned on slopes ranging from 30°-60° at 2,000-3050m (National Park Service, 2019). Pregnant grizzly bears were found to den at higher elevations than males and non-pregnant females (National Park Service, 2019). Stevens & Gibeau (2005) found that Alberta grizzly bears in the Rocky Mountains did not have a preference for a specific orientation or aspect, but did ensure their dens would be covered in deep snow and sheltered from strong winds. Black bears in British Columbia mostly choose large diameter trees or stumps to den in, whereas grizzly bears prefer to excavate their dens or use caves in the alpine (Ciarniello *et al*., 2005, Province of British Columbia, 2001). It is rare for black and grizzly bears to re-use den sites, unless the den is a durable structure such as a cave (Ciarniello *et al*., 2005, Stevens & Gibeau, 2005). There is evidence that bears will sometimes return to den in close proximity of previous den sites (Ciarniello *et al*., 2005).

Since bears are in a state of torpor in their den, they can be easily disturbed by human activity and leave the den in search of a safer space, which would likely result in death for the bear (Goldstein *et al*., 2010; Guppy, 2009). Bears are sensitive throughout the denning period, so human activities and noise should be minimized in areas with denning bears (Linnell *et al*., 2000). Good denning habitat can be identified as an area that has evidence of a den being used in the last two years (Guppy, 2009). Guppy

(2009) provided guidelines for British Columbia regarding the protection of grizzly bear dens, such as prohibiting low-level machine activity within 250m of a den, and high-level machine activity within 500m of a den. Guppy (2009) also recommended that prior to developing, consult a professional to help maintain a 200m buffer zone around dens that had been used in the last two years.

Some creeks and rivers have natural features that collect salmon carcasses such as logjams or gravel bars; these areas should be avoided due to high frequencies of bears (MacHutchon, 2000). High-value wildlife habitat and old or mature growth forests are rare and sparsely distributed, so trails should not be sited in those areas (MacHutchon, 2016). The presence of scat, tracks, mark trees, bear trails, and evidence of feeding are some signs to determine habitat use by bears (Hererro *et al.*, 1986). Herrero *et al*. (1986) recommend building trails away from important large carnivore habitat in order to reduce the chances of interaction with people. Miller *et al*. (2020) suggested using geospatial mapping data to determine information about the landscape; through this information, high-quality animal habitat can be accurately identified and avoided to reduce impacts to wildlife and the risk of human-wildlife interaction. Topographic maps, rivers and wetlands layers, and even some wildlife habitat or population information layers are available on the Government of British Columbia website.

*Demand Management*

In the case of trail development, it is important to forecast future demands of usage in a particular area, and plan how to sustainably manage those demands (Miller *et al*., 2020). Demand management uses the carrying capacity and trail density of a proposed trail system to determine if it is reasonable to move forward with construction. If demands are too high, the ecosystem may not be able to withstand the pressure, and this could have grave consequences for the wildlife that live there.

Carrying capacity is defined as the maximum population size of species that an area can sustain with the natural resources available (Prato, 2001). Extensive human use of trails and wilderness areas can lead to destruction of habitat, lowering the carrying capacity of that area (Lucas, 2020). When carrying capacity is exceeded, the ecosystem becomes unstable, and there may be a reduction in biodiversity,

carbon sequestration, and primary productivity, among other detrimental effects (Chapman & Byron, 2018). There may also be permanent damage to future functioning of the ecosystem, as well as a reduction in future carrying capacity (Rees, 2013). A Visitor Use Management framework was created by The Interagency Visitor Use Management Council, which is a multi-step guided process that can be used to make better decisions on carrying capacity and ultimately minimize impacts by recreationists (Marion, 2016). In addition, Nickel *et al*. (2020) recommend using spatial data to forecast activity levels of humans, and determine if there is capacity to increase anthropogenic use of wild areas.

Areas with high trail density will displace wildlife through heightened disturbance (Lucas, 2020; MacHutchon, 2016). Large carnivores tend to avoid areas with high human use, pushing them into less optimal habitats for hunting and foraging, which can result in lower energy for survival and reproduction (MacHutchon, 2000). The zone of human influence refers to the distance from a trail an animal will avoid due to human activity (MacHutchon, 2016). The zone of human influence averages from 50-200m, and varies between species, individual animals, and their level of habituation (MacHutchon, 2016; Rogala *et al*., 2011). Accounting for the zone of human influence dramatically reduces the area of what would be classified "undisturbed habitat" (eg. any land up to 200m of a trail would no longer be considered undisturbed; MacHutchon, 2016). Reducing trail density and avoiding wide or paved trails reduces impacts to wildlife (MacHutchon, 2016; Miller *et* al., 2020). The BCEAG (2012) recommends developing a linear trail density threshold by using a geographic information system (GIS) to take inventory of current trails in the area being considered for new development. In using this threshold, one can determine if further trail development should be permitted in that area. Miller *et al.* (2020) also stressed the importance of maintaining wildlife corridors and avoiding unfragmented areas for trail development, as this can protect wildlife and reduce human-wildlife interactions.

*Intended Use of Trail*

In the planning stages of trail building, planners have to consider what type of recreation the trail will be used for. This includes determining if the trail will be predominantly used in a certain season or if

it will be used year-round. The movement and activity of large carnivores changes based on the season and time of day (Miller *et al*., 2020). Another important consideration is the speed at which recreationists move on the trail, as this affects the potential for surprise encounters with wildlife and can lead to conflict incidents (MacHutchon, 2016).

Considering seasonal patterns of animal movements is essential to trail building as many animals are more sensitive to human disturbance at certain times of the year (Miller *et al*., 2020). Recreationists have a larger negative impact on wildlife in winter, as it requires more energy for movement and survival, especially with less food available in winter months (Miller *et al*., 2020). Grizzly bears in the Rocky Mountains of Alberta and south-central Alaska were found to den at high elevations on steep slopes, isolated from human activity (Goldstein *et al.*, 2010). Humans recreating near den sites, especially those in large groups or with dogs, can disturb denning bears which is not only energetically costly to the bear, but could also increase the risk of a conflict incident (Goldstein *et al.*, 2010; MacHutchon, 2000). If a trail is to be designed primarily for winter use, it is imperative to avoid prime denning habitat for bears (Goldstein *et al*., 2010). In addition, seasonal trail closures should be considered, and will be discussed further in the Maintenance/Operations phase of trail development.

In this review there is a focus on non-motorized recreation, specifically hiking, trail running, and mountain biking. Non-motorized recreation has a stronger negative effect than motorized recreation for some mammal species (Miller *et al.*, 2020). This could be due to humans on foot appearing more threatening to animals than those in vehicles (Miller *et al*., 2020). Lucas (2020) found that hikers and runners have a strong negative impact on some mammals and caused temporal displacement and temporary spatial displacement. Of course, motorized recreation has negative impacts on wildlife as well, especially due to the large distances that can be travelled, noise produced, and damage to vegetation (Miller *et al*., 2020).

Activities involving high speed travel and quiet approaches cause disturbances to wildlife and increase the risk of conflict with animals (MacHutchon, 2016; Miller *et al*., 2020). High-speed recreationists, such as mountain bikers and trail runners, are more likely to have surprise encounters

(defined as approaching within 50m before the animal is aware of human presence) with large carnivores (MacHutchon, 2016). Large carnivores, especially bears, feel threatened by surprise encounters, and there is a higher probability of an attack occurring (Herrero, 2018). In a study on 33 grizzly bear encounters with mountain bikers, the majority of bears (88%) charged or chased the bicyclists (MacHutchon, 2016). Trail features that allow mountain bikers to travel at high speeds include but are not limited to: flat trails, moderate downhills, smooth terrain surfaces, and wide trails (MacHutchon, 2016). Since travelling at a faster speed increases the risk of sudden encounters and human-wildlife conflict, it is essential to incorporate features that minimize the speed of recreationists. In areas of prime large carnivore habitat, especially grizzly bears, it would be appropriate to create mountain biking trails that avoid speed enhancing features as described above (MacHutchon, 2016).

## Design Phase

Once a general location for a trail or trail system has been chosen and its purpose of use has been determined, it is now time to design the trail. By taking overt reaction distances of animals into consideration, trail developers can determine sightlines, which influence how humans and animals respond when they encounter each other on the trail.

### *Overt Reaction Distance*

The overt reaction distance (ORD) refers to the threshold of space an animal will withstand between a human or another animal before it responds (the response can range from lifting head, to fleeing, to an aggressive response) (Smith *et al*., 2005). Smith *et al*. (2005) found in areas with high densities of bears, habituation is more common, and the ORD of these bears is smaller. Smaller ORDs mean it is less likely for a human to provoke an aggressive response from the bear (Smith *et al*., 2005). In areas with a high bear density, there may be increased food availability, which could explain a more relaxed response to humans (Smith *et al*., 2005). In contrast, areas with low densities of bears tend to see bears with long ORDs, meaning even if a human is far away, it may still elicit a reaction from the bear

(Smith *et al*., 2005). It is impossible to know the ORD of individual animals, therefore; it is important to give large carnivores as much space as possible and take precautions to avoid encounters with them.

*Sightlines*

Large carnivores tend to exhibit strong behavioural responses to the sudden arrival of humans (Nickel *et al.*, 2020), so trail designers should prioritize the establishment of broad sightlines (MacHutchon, 2016). Sightlines refer to the distance recreationists can see in either direction the trail is headed (Government of Alberta, 2019c). There are several things that can impede sightlines on trails, including vegetation, tight corners, and blind hills. Thick vegetation can reduce the ability of people and animals to detect each other until within close range (MacHutchon, 2016). Since sudden encounters with wildlife can occur within 50m, having at least a 50m line of sight would be ideal to avoid conflict (MacHutchon, 2016).

Some types of vegetation may also attract wildlife that use plants as a food source, such as bears (MacHutchon, 2016). A bear's diet is very complex and varies by geographic location, and time of year (Munro *et al.*, 2006). The diet of coastal and Rocky Mountain grizzly bears consists of 85% plant material, including roots, seeds, grasses, skunk cabbage, berries, sedges, and many other plant species (Denning, 1998). MacHutchon (2016) proposed that vegetation, especially fruit-bearing shrubs, be cut back or thinned out along trails, as this will improve sightlines and discourage bears from feeding there. Cutting back dense vegetation on narrow trails at least half a metre on each side can reduce the chances of surprise encounters with wildlife, and in turn reduce conflict with wildlife (MacHutchon, 2016). It is best to avoid building trails in areas where there are high concentrations of plant foods for wildlife, particularly in dense poplar and alder, but rather use open areas with high visibility, such as moraines (MacHutchon, 2000). The sensory barriers produced by dense forest cover may induce a false sense of security in animals that use these areas, which is another reason to avoid building trails in these areas. It is difficult in some cases to reduce impacts to wildlife while also attempting to minimize human-wildlife conflict risk.

Maintenance/Operations Phase

Once a trail is planned, developed, and in the ground, minimizing impacts to wildlife and reducing human-wildlife conflict largely involves managing trail users. This can be accomplished by installing signage, enforcing trail closures, and minimizing wildlife attractants.

*Signage*

A lack of education surrounding wildlife safety can put people and animals in danger (MacHutchon, 2016). Recreational trails should have effective signage to educate users of potential risks and ways they can minimize their impact on wildlife. It is important to provide information that improves human appreciation for wildlife and explains the negative consequences to wildlife when Park guidelines are ignored (MacHutchon, 2016).

If a trail is not well built or maintained, it may be unclear where the official trail is. Signage and enforcement can be used to encourage people to stay on the trail, and reduce the chances of encountering wildlife or damaging vegetation (MacHutchon, 2016). Marion (2016) found that persuasive signage asking people to stay on the trail and avoid certain areas was indeed effective, and most people were willing to follow the directions given.

*Closure Considerations*

In summer months, human use of recreational trails is generally higher at midday, with less activity near dawn and dusk (MacHutchon, 2016). Wolves, cougars and bears become accustomed to daily activity levels of humans and adapt by hunting between dawn and dusk or on weekdays, when less people are around (MacHutchon, 2016). When humans recreate near sunrise or sunset, they are at much higher risk of encountering a large carnivore, which can result in conflict (MacHutchon, 2016). Nighttime trail closures (eg. from sunset to sunrise) would give animals a chance to feed free of human presence and could reduce human-wildlife interactions (MacHutchon, 2016).

Trails with heavy human use in the spring could be closed during that season to protect large carnivore species with babies (BCEAG, 2012). If trails are built near wolf homesites, implementing trail closures during wolf denning periods would reduce negative impacts to these vulnerable animals and their pups (Frame *et al*., 2007). Female wolves will sometimes abandon their den or homesite as a result of human disturbance, which puts the pups at risk and expends a lot of energy as they move to a new den (Frame *et al*., 2007). Trail closures may need to be adjusted on a yearly basis, depending on the level of risk to wildlife. For example, if a bear den is found near a winter trail, a trail closure might be considered to minimize noise disturbance.

Visitor use of trail systems should be monitored over time to determine if adjustments are necessary regarding closures or restricting access (Leung *et al*., 2018). Tracking the impacts of recreationists can be recorded via camera and video monitoring equipment or visitor counting methods (Leung *et al*., 2018). To manage excessive visitor use, parking lots can be made smaller, permit systems implemented, and enforcement can aid in restricting access when capacity is reached (Interagency Visitor Use Management Council, 2016).

*Attractant Management*

Part of the maintenance phase of trail building includes managing natural and anthropogenic wildlife attractants, as this will reduce the chance of human-wildlife interactions (MacHutchon, 2016). When building the trail, vegetation should be cut back in order to ensure adequate sightlines (MacHutchon, 2016). Every couple of years, it is important to trim down the vegetation again as it starts to impede sightlines on the trail (MacHutchon, 2016). Graminoids and fruit-bearing shrubs, both key food sources for bears, grow particularly well along trail systems, as these areas receive more sunlight (MacHutchon, 2016). In areas with high concentrations of these plants, maintenance may be particularly important for limiting interactions between humans and bears (MacHutchon, 2016).

Anthropogenic foods are any foods that do not occur naturally, but are provided by humans (MacHutchon, 2016). Garbage produced by humans attracts wolves and bears, and should be secured in

bear-resistant garbage bins (MacHutchon, 2016). When animals have access to human garbage, they can become food-conditioned, which can lead to aggressive interactions with humans, and sometimes death for the human or the animal (MacHutchon, 2016). In areas with large carnivores, it is essential to have bear-resistant bins at every trailhead, and these bins need to be emptied often and checked for proper functionality (MacHutchon, 2016). Signage plays an important role in educating trail users on the importance of attractant management.

**Conclusion**

As more people recreate in nature each year, pressure on our ecosystems and wildlife species is mounting. Mountain biking, trail running, and hiking have substantial negative impacts on large carnivores (Lucas, 2020; MacHutchon 2000; 2016; Miller *et al.,* 2020). These non-motorized activities displace animals from their territory, cause habitat fragmentation, and place energetically costly stress on animals (MacHutchon, 2016; Miller *et al*., 2020). Additionally, with the overlap of human activities and wildlife habitat, there is an increasing risk of human-wildlife conflict, which can lead to the death of humans and animals (Marion *et al*., 2016; MacHutchon, 2016). We examined the available literature to provide guidelines which will help reduce the impact of future trail systems on large carnivores and minimize opportunities for human-wildlife encounters. These guidelines will be useful throughout the planning, design, and maintenance/operations phases of trail building.

Previous literature was consistent in that non-motorized recreation does have negative impacts to large carnivore species and also contributes to a loss of biodiversity (Lucas, 2020; MacHutchon 2000; 2016; Miller *et al.*, 2020). Non-motorized recreation, especially activities involving quiet and high-speed movement can result in sudden encounters with large carnivores, which may elicit an aggressive response from the animal (Hererro *et al.*, 1986; MacHutchon, 2016; Miller *et al*., 2020). Although recreational trails are important for tourism economies and the health and well-being of humans (MacHutchon, 2000; 2016; Miller *et al.,* 2020), development of new trail systems should be organized and conducted responsibly.

The guidelines provided in this review covered three main phases of trail system development: planning, design, and maintenance/operations. Location of the proposed trail system is determined in the planning phase and is possibly the most important decision in minimizing impact to large carnivores. Ideally, a location with low quality wildlife habitat or minimal wildlife presence would be best suited for trail development (MacHutchon, 2000). As discussed, the carrying capacity and intended use of the trail system is also important in determining a location for development. Design features such as improved sightlines can be helpful in minimizing sudden encounters and human-wildlife conflict (MacHutchon, 2016). The maintenance/operations phase of trail development largely involves managing trail users. Providing educational signage, enforcing trail closures, and reducing wildlife attractants are key factors in decreasing human-wildlife conflict (BCEAG, 2012; MacHutchon, 2016). By considering these recommendations, trail developers will contribute to a safer experience for recreationists and minimize the impacts of trail systems to large carnivores.

The literature examined failed to cover the various phases of trail developments and factors to consider in each stage. Most of the available literature prior to this review had a narrow focus either on one aspect of trail development or one species of large carnivore, and very few articles discussed both the impact of trail systems to wildlife and human-wildlife conflict. Most of the information available on recreation impacts to large carnivores involved bear species; it was difficult to gather data on wolves and cougars. More data are needed regarding trail density, wildlife density, and carrying capacity, as this information is needed to determine if an area can handle additional recreational trails. Furthermore, understanding the average overt reaction distances of various large carnivore species would be useful in establishing more appropriate sightline distances when designing trails. In recent years, outdoor recreation has grown significantly, and there are more people recreating outdoors than ever before (Miller *et al*., 2020). This means there are much higher volumes of people than research in prior years has taken into account. An updated analysis should be done to determine how record-breaking numbers of visitors impact wildlife in natural areas.

The recommendations provided in this article are important to consider when building trails, as they will minimize impact to wildlife and reduce human-wildlife conflict incidents. Adhering to the guidelines can contribute to the conservation of large carnivore species and promote safe and enjoyable recreation for humans. Trail developers have a responsibility to carefully make decisions to alter the dwindling wild spaces remaining and should not take those decisions lightly. Further developments of wildlife habitat should be carefully considered and responsibly executed. In doing so, we can balance the needs of both wildlife species and humans, and ensure the sustainability of our natural ecosystems.

**References**

Anderson, R. C. (2006). Evolution and origin of the Central Grassland of North America: Climate, fire, and mammalian grazers. *The Journal of the Torrey Botanical Society*, *133*(4), 626-647. https://doi.org/10.3159/1095-5674(2006)133[626:EAOOTC]2.0.CO;2

BC Gov News. (2017, January 24). *Factsheet: Mountain caribou and wolves.* https://news.gov.bc.ca/09403

Bischoff-Mattson, S. (2019). *Habitat preference and use by the Cougar (Puma concolor)* [unpublished master's thesis] Duke University. https://hdl.handle.net/10161/18385

Blake, L. W., & Gese, E. M. (2016). Resource selection by cougars: Influence of behavioral state and season. *The Journal of Wildlife Management*, *80*(7), 1205-1217. https://doi.org/10.1002/jwmg.21123

Bombieri, G., Penteriani, V., Almasieh, K., Ambarlı, H., Ashrafzadeh, M. R., Das, C. S., ... & del Mar Delgado, M. (2023). A worldwide perspective on large carnivore attacks on humans. *PLOS Biology*, *21*(1). https://doi.org/10.1371/journal.pbio.3001946

Bow Corridor Ecosystem Advisory Group. (2012). *Wildlife corridor and habitat patch guidelines for the Bow Valley*. Edmonton, Alberta Environmental Protection. (original work published 1998). https://doi.org/10.5962/bhl.title.115217

Chapman, E. J., & Byron, C. J. (2018). The flexible application of carrying capacity in ecology. *Global Ecology and Conservation*, *13*. https://doi.org/10.1016/j.gecco.2017.e00365

Ciarniello, L. M., Boyce, M. S., Heard, D. C., & Seip, D. R. (2005). Denning behavior and den site selection of grizzly bears along the Parsnip River, British Columbia, Canada. *Ursus*, *16*(1), 47-58. https://doi.org/10.2192/1537-6176(2005)016[0047:DBADSS]2.0.CO;2

Danell, K., Duncan P., Bergstro¨m R., & Pastor, J. (Eds.). (2006). *Large herbivore ecology, ecosystem dynamics and conservation* (Vol. 11). Cambridge University Press.

Denning, D. (1998). *Grizzly Bear Biology: Concepts and activities: Student guide.* Queen's Printer.

Dickman, A. J. (2010). Complexities of conflict: The importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation*, *13*(5), 458-466. https://doi.org/10.1111/j.1469-1795.2010.00368.x

Elbroch, L. M., Lendrum, P. E., Alexander, P., & Quigley, H. (2015). Cougar den site selection in the Southern Yellowstone Ecosystem. *Mammal Research*, *60*, 89-96. https://doi.org/10.1007/s13364-015-0212-6

Environmental Reporting BC. (2020, November). *Grizzly Bear Population Ranking in B.C.* State of Environment Reporting, Ministry of Environment, British Columbia, Canada. https://www.env.gov.bc.ca/soe/indicators/plants-and-animals/grizzly-bears.html

Frame, P. F., Cluff, H. D. & Hik, D. S. (2007). Response of wolves to experimental disturbance at homesites. *The Journal of Wildlife Management*, *71*(2), 316-320. https://doi.org/10.2193/2005-744

Goldstein, M. I., Poe, A. J., Suring, L. H., Nielson, R. M. & McDonald, T. L. (2010). Brown bear den habitat and winter recreation in South-Central Alaska. *The Journal of Wildlife Management*, *74*, 35-42. https://doi.org/10.2193/2008-490

Government of Alberta. (2019a). *Cougar occurrence summary: Human-cougar coexistence in the Bow Valley.* https://open.alberta.ca/dataset/314e2bdd-08c0-48d0-bc21-2f871b04af71/resource/bc5f7c93-80bb-4c79-a382-03eefe6b63da/download/aep-cougar-occurrence-summary-2000-2018.pdf

Government of Alberta. (2019b). *The BearSmart guide to playing safely in bear and cougar country.* https://open.alberta.ca/dataset/595754dd-31f9-4417-973c-237775ec6615/resource/01eff3c4-4893-4cbd-8a82-a7fbc5a8cae9/download/bearsmart-bear-safety-booklet-2019.pdf

Government of Alberta. (2019c). *Trail development guidelines for Alberta's public land: A guide to the planning, classification, design, construction and management of trail experiences on public land.* https://open.alberta.ca/dataset/b1cae0e7-4b70-4c7b-8575-

f89ada15342d/resource/9cc04dc8-ffe5-4c04-aed4-ff43cee2cb56/download/aep-trail-development-guidelines-2019.pdf

Government of Canada. (2017a, July 5). *American black bear: non-detriment finding.* https://www.canada.ca/en/environment-climate-change/services/convention-international-trade-endangered-species/non-detriment-findings/american-black-bear.html

Government of Canada. (2017b, July 5). *Cougar: non-detriment finding.* https://www.canada.ca/en/environment-climate-change/services/convention-international-trade-endangered-species/non-detriment-findings/cougar.html

Government of Canada. (2022a, November 19). *Grey wolf (Canus lupus) – Pukaskwa National Park.* https://parks.canada.ca/pn-np/on/pukaskwa/nature/faune-wildlife/mammiferes-mammals/loup-wolf

Government of Canada. (2022b, November 26). *Grizzly bears – Bears in the mountain national parks.* https://parks.canada.ca/pn-np/mtn/ours-bears/generaux-basics/grizzli-grizzly

Guppy, C. S. (2009). *Field guide to wildlife habitat management.* BC Timber Sales Cariboo-Chilcotin Business Area, Ministry Forests and Range. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/bc-timber-sales/ems-sfm-certification/business-area/cariboo-chilcotin/tcc-field-guide.pdf

Herrero, S. (2018). *Bear attacks: their causes and avoidance*. Rowman & Littlefield.

Herrero, S., McCrory, W., & Pelchat, B. (1986). Using grizzly bear habitat evaluations to locate trails and campsites in Kananaskis Provincial Park. *Bears: Their Biology and Management*, *6*, 187-193. https://doi.org/10.2307/3872824

Hofmeester T. R., Jansen P. A., Wijnen H. J., Coipan E. C., Fonville M., Prins H. H. T., Sprong H., & van Wieren S. E. (2017). Cascading effects of predator activity on tick-borne disease risk. *Proceedings of the Royal Society B*, *284*(1859). https://doi.org/10.1098/rspb.2017.0453

Interagency Visitor Use Management Council (U.S.) (2016). *Visitor use management framework: A guide to providing sustainable outdoor recreation.* National Park Service.

https://visitorusemanagement.nps.gov/Content/documents/VUM_Framework_Edition%201_508%20Compliant_IVUMC.pdf

Laliberte A. S., & Ripple W. J. (2004). Range contractions of North American carnivores and ungulates. *BioScience*, *54*(2), 123–138. https://doi.org/10.1641/0006-3568(2004)054[0123:RCONAC]2.0.CO;2

Leung, Y. F., Spenceley, A., Hvenegaard, G., Buckley, R., & Groves, C. (2018). T*ourism and visitor management in protected areas: Guidelines for sustainability* (Vol. 27). Gland, Switzerland: IUCN. https://doi.org/10.2305/IUCN.CH.2018.PAG.27.en

Linnell, J. D., Swenson, J. E., Andersen, R., & Barnes, B. (2000). How vulnerable are denning bears to disturbance? *Wildlife Society Bulletin*, *28*(2), 400-413. https://www.jstor.org/stable/3783698

Lino, A., Fonseca, C., Rojas, D., Fischer, E., & Pereira, M. J. R. (2019). A meta-analysis of the effects of habitat loss and fragmentation on genetic diversity in mammals. *Mammalian Biology, 94*, 69–76. https://doi.org/10.1016/j.mambio.2018.09.006

Lucas, E. (2020). Recreation-related disturbance to wildlife in California—Better planning for and management of recreation are vital to conserve wildlife in protected areas where recreation occurs. *California Fish and Wildlife: Effects of Non-consumptive Recreation on Wildlife in California*, *106*, 29–51.

MacHutchon, A. G. (2000). *Risk Assessment of Bear–Human Interaction at Campsites on the Tatshenshini River and Lower Alsek River, Yukon, BC, and Alaska.* BC Parks. https://corpora.tika.apache.org/base/docs/govdocs1/172/172435.pdf

MacHutchon, A. G. (2016). *Human-Wildlife Interaction Risk Assessment for the Sea to Sea Green Blue Belt and Sooke Hills Wilderness Regional Park Reserves*. CRD Parks.

Marion, J. L. (2016). A review and synthesis of recreation ecology research supporting carrying capacity and visitor use management decisionmaking. *Journal of Forestry*, *114*(3), 339-351. https://doi.org/10.5849/jof.15-062

Marion, J. L., Leung, Y. F., Eagleston, H., & Burroughs, K. (2016). A review and synthesis of recreation ecology research findings on visitor impacts to wilderness and protected natural areas. *Journal of Forestry*, *114*(3), 352-362. https://doi.org/10.5849/jof.15-498

Martin, K. M., (2001). Wildlife in alpine and sub-alpine habitats. In Johnson, D. H. & O'Neil, T. A. (Managing Directors), *Wildlife-habitat relationships in Oregon and Washington.* (pp. 285-310). Oregon State University Press.

Miller, A. B., King, D., Rowland, M., Chapman, J., Tomosy, M., Liang, C., Abelson, E. S., & Truex, R. (2020). *Sustaining wildlife with recreation on public lands: a synthesis of research findings, management practices, and research needs.* U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Munro, R. H. M., Nielsen, S. E., Price, M. H., Stenhouse, G. B., & Boyce, M. S. (2006). Seasonal and diel patterns of grizzly bear diet and activity in west-central Alberta. *Journal of Mammalogy*, *87*(6), 1112-1121. https://doi.org/10.1644/05-MAMM-A-410R3.1

Naoe S., Tayasu I, Sakai Y., Masaki T., Kobayashi K., Nakajima A., Sato Y., Yamazaki K., Kiyokawa H., & Koike S. (2016). Mountain-climbing bears protect cherry species from global warming through vertical seed dispersal. *Current Biology*, *26*(8), R315-R316. https://doi.org/10.1016/j.cub.2016.03.002

National Park Service. (2019, September 18). *Denning and hibernation behaviour.* https://www.nps.gov/yell/learn/nature/denning.htm

National Park Service. (2022a, February 16). *Visitation numbers.* https://www.nps.gov/aboutus/visitation-numbers.htm

National Park Service. (2022b, July 5). *Subalpine ecosystem.* https://www.nps.gov/romo/learn/nature/subalpine_ecosystem.htm

Nickel B. A., Suraci J.P., Allen M.L., & Wilmers C. C. (2020). Human presence and human footprint have non-equivalent effects on wildlife spatiotemporal habitat use. *Biological Conservation*, *241*. https://doi.org/10.1016/j.biocon.2019.108383

Paquet, P. C., & Carbyn, L. N. (2003). Gray wolf. *Wild mammals of North America: biology, management, and conservation*, 482-510.

Prato, T. (2001). Modeling carrying capacity for national parks. *Ecological Economics*, *39*(3), 321-331. https://doi.org/10.1016/S0921-8009(01)00248-8

Province of British Columbia. (2001). *Black bears in British Columbia: Ecology, Conservation and Management.* https://www.env.gov.bc.ca/wld/documents/blackbear.pdf

Rees, W. E., (2013). Ecological footprint, concept of. *Encyclopedia of Biodiversity (Second Edition),* 701-713. https://doi.org/10.1016/B978-0-12-384719-5.00037-X

Rieth, W. R. (2010). *Cougar resource selection in two mountain ranges in Utah: a study on scale and behavior*. (Publication No. 698) [Master's thesis, Utah State University]. All Graduate Theses and Dissertations. https://doi.org/10.26076/65ea-63d4

Rogala, J. K., Hebblewhite, M., Whittington, J., White, C. A., Coleshill, J., & Musiani, M. (2011). Human activity differentially redistributes large mammals in the Canadian Rockies National Parks. *Ecology and Society*, *16*(3). https://www.jstor.org/stable/26268938

Scudder, G.G.E & Smith, I.M. (2011). Introduction and Summary of the Montane Cordillera Ecozone. In Scudder, G.G.E & Smith, I.M. (Eds.), *Assessment of Species Diversity in the Montane Cordillera Ecozone.* (pp. 1-26).

Smith, T. S., Herrero, S., & DeBruyn, T. D. (2005). Alaskan brown bears, humans, and habituation. *Ursus*, *16*(1), 1-10. https://www.jstor.org/stable/3873054

Stevens, S. & Gibeau, M. (2005). Research methods regarding capture, handling and telemetry. In Herrero, S. (Ed.), *Biology, demography, ecology and management of grizzly bears in and around Banff National Park and Kananaskis Country: The final report of the Eastern Slopes Grizzly Bear Project.* (pp. 224-226). Faculty of Environmental Design, University of Calgary, Alberta, Canada.

Washington Department of Fish and Wildlife. (n.d.). *Cougar (puma concolor).* https://wdfw.wa.gov/species-habitats/species/puma-concolor#conflict

Willoughby M. G., Archibald J. H., Klappstein G. D., Corns I. G. W., Beckingham J. D., Wilson, B. E., DeMaere C., Baker H., Alexander M. J., & Downing, D. J. (2021). *Guide to ecological sites of the montane subregion. Fourth approximation.* Government of Alberta. https://open.alberta.ca/dataset/ff78e497-9f68-4433-b881-fd32064e290e/resource/4662ed1b-e7a6-4f46-b46e-9f814367fb78/download/af-ecological-sites-montane-subregion-fourth-approximation-2021-03.pdf


Outdoor Recreation
Council of BC