GOLF COURSES AND WILDLIFE: A LITERATURE REVIEW

Assessing the Current State of Knowledge of Golf Course Compatibility for Selected Wildlife

Prepared for Alberta Environment
August 20, 2000.

MIISTAKIS INSTITUTE
FOR THE ROCKIES

The Miistakis Institute for the Rockies (MIR) exists to build our collective capacity for transboundary ecosystem management. Offering innovative communication and information services, we promote collaboration between various interests in the Rockies of British Columbia, Alberta, and Montana. Our work reduces conflict in land-based planning exercises by offering a common, non-partisan information base to all stakeholders.

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Acknowledgements
Miistakis Institute for the Rockies greatly appreciates the individuals who provided anecdotal information and documents applicable to this literature review. Many wildlife biologists, researchers, superintendents and environmental consultants from Alberta, British Columbia, Montana, Idaho, Wyoming and Colorado assisted in providing information for this literature review.

Title page photo of mother bear and two cubs crossing the Nicklaus North Golf Course, Whistler, British Columbia, courtesy of Audubon International.

Executive Summary

The Miistakis Institute for the Rockies was contracted by Alberta Environment to document the current state of knowledge on the impact of golf courses on ungulates, carnivores and fur-bearers. In particular, the review focused on the compatibility/incompatibility of golf courses in relation to movement corridors and habitat use. The search strategy consisted of two components, an assessment of the current literature derived through electronic databases and a compilation of anecdotal information derived through personal contacts. The literature review prioritized examples and anecdotal evidence of golf courses within the Rocky Mountains.

There were very few studies found, with the exception of elk, which assessed wildlife movements and habitat use prior to and post golf course development. Therefore, studies were reviewed which assessed the sensitivity of specific species to habitat alteration and an increase in human presence. These studies, combined with anecdotal observations, formed the basis for this report.

A golf course may impact wildlife by altering habitat, by increasing human presence, by displacing individuals, by shifting movement patterns, by altering interspecific competition and/or by contributing to indirect or direct mortality. In general, the impact of a golf course on wildlife will vary depending upon the wildlife species, the golf course context, the amount of habitat alteration, and the level of human presence. Some species may be attracted to, while others are displaced from the altered habitat on a golf course, but as humans increase, habitat effectiveness is reduced for most species. As human presence and associated developments increase so does the likelihood of wildlife displacement, either through the species own intolerance or through management action. Wildlife may continue to use the area as a movement corridor however this may be compromised as well depending upon the level of human presence, the availability of attractants and the level of physical construction attending the course. Therefore, in general, there appears to be very few long-term benefits to wildlife living near a golf course.

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1.0 INTRODUCTION

The Miistakis Institute for the Rockies was contracted by Alberta Environment to document the current state of knowledge on the impact of golf courses on ungulates, carnivores and fur-bearers. This literature review focuses on the compatibility of golf courses in relation to habitat use and movement corridors. Where applicable, design characteristics that may enhance a golf course's compatibility for wildlife are outlined. The literature review prioritizes examples and anecdotal evidence of golf courses within the Rocky Mountains. It is not focused on a specific golf course development but provides a general overview of potential impacts of golf courses on selected Rocky Mountain wildlife species.

This literature review is not a comprehensive survey of the impacts of golf courses on the environment. It does not include information on the potential impacts to water and soil quality, drainage patterns, and of chemical applications. In addition, it focuses on carnivore and ungulate species. Information on other taxa, such as birds and small mammals, are limited in this review (a list of some relevant bird and small mammal references are listed in Appendix C). Amphibians, reptiles and aquatic species are not addressed.

During the review it became apparent that there were very few scientific surveys published on the impacts of golf courses on wildlife corridors or habitat use. However many wildlife biologists and researchers provided anecdotal information for specific species. In addition, a number of surveys have assessed the sensitivity of specific species to human presence and habitat alteration. This information can be cautiously applied to golf courses depending upon the specifics of the proposed development.

Miistakis does not address the issue of comparing the potential environmental impacts of different development scenarios. This consideration is left up to the planning body and the various groups involved in the assessment of the proposed golf course. This review assumes that we are converting a natural area to a golf course within the Rocky Mountains.

Finally there are two important studies from the Canmore area that are not included but which specifically address the compatibility of golf courses as Rocky Mountain wildlife habitat. These studies include a seven year review of large mammal use on the Silvertip Golf Course and information from wildlife tracking biologists working on the Stewart Creek Golf Course for Three Sisters Development Corporation. Miistakis was not able to acquire either of these reports. Given the deficiency of direct information regarding the impact of golf courses on wildlife in the Rocky Mountains these reports represent an important source of information and should be read in conjunction with this literature review.

2.0 METHODOLOGY

The Miistakis search strategy had two components, an assessment of the current gray and white literature derived through electronic databases and library catalogues and a compilation of anecdotal information through personal contacts.

An intensive search was undertaken using interlibrary electronic databases accessed from the University of Calgary, Alberta Environment and the World Wide Web. Each database was searched using keywords and linked keywords. The complete search documentation is detailed in Appendix A.

The search also included personal communications with the following types of individuals:
- golf course superintendents;
- researchers working on/near golf courses;
- wildlife biologists/district managers responsible for wildlife on/near golf courses;
- and golf course developers and environmental consultants.

Individuals were asked questions based on guidelines documented in Appendix B. A detailed list of the contacts has also been documented in Appendix B.

3.0 BACKGROUND INFORMATION

When considering the impacts of development on wildlife species it is important to have a general understanding of landscape ecology and community dynamics. These factors contribute to our understanding of the cumulative effects of a development on wildlife species.

3.1 Landscape Ecology

Landscape ecology is the study of the generation and consequences of broad scale spatial patterning on the landscape. A landscape is viewed as a compilation of matrices, patches and corridors formed by vegetation, topography and other physical factors at various scales (Forman, 1995). A matrix is the background ecosystem or the land use type (e.g. mountain forest), a patch is a non-homogenous area that differs from the matrix (e,g. subalpine meadow) and a corridor is a linear strip that usually connects patches (e.g. riparian corridor). The matrix and the type of corridors and patches on the landscape determine the suitability of the landscape to support different species. Landscape ecology assists the land manager in identifying preferred wildlife habitat and movements in terms of these patches and corridors (Hunter, 1996). A golf course will likely change the landscape matrix to varying degrees and, in turn, will likely alter the pattern and distribution of species on the landscape.

Habitat fragmentation occurs when wildlife habitat is divided and/or when movement corridors are blocked. As natural areas are developed, biologists should consider the impacts of habitat fragmentation and isolation on specific species. The diverse topography in the Rockies, in conjunction with slope angles, extreme elevations and dense vegetation, limits many species to using valley bottoms. This is also where human development is concentrated and widespread (Heuer et al., 1998). Fragmentation may affect the daily and/or seasonal movements of species. This may result in isolated species populations, an increased possibility of inbreeding, the alteration of predator-prey dynamics, the loss of mate choice and/or a loss of food resources (Thomas, 1991). In addition, fragmentation and competition are directly linked because alteration of vegetation mosaics in the landscape provide ideal habitat for generalists which out compete habitat specialists (Buskirk et al., 1999).

Since a golf course will likely alter the landscape ecology of an area, designs should minimize the loss of important patches and corridors. Changes in the habitat of an animal may also alter the behavior, survival, reproduction and distribution of individuals. Consequently, the community dynamics may be altered as population sizes change and species are displaced (Anderson, 1995).

3.2 Community Dynamics

Very few studies have considered the effect of recreation on community dynamics and structure. Community dynamics describe the interplay between various species and their environment. For instance, recreational activities have the potential to alter interspecific competition and predator-prey relationships, both of which alter community dynamics and structure (Gutzwiller, 1995). Prey presence or absence in an area can affect the feeding structure and the path of energy and nutrient flows. Removing a single species from a system may affect many other species to varying degrees of intensity – improving the lot of some and harming the chances of others. Displaced individuals may have to survive in areas where they do not know the location of resting, water and feeding spots, placing them at a disadvantage over resident individuals (Gutzwiller, 1995). Community and species tolerance will vary and it is, therefore, important to understand what species require on a regional and landscape scale and what dependencies ripple throughout the system (Hickman et al, 1998). A golf course that changes the matrix of the landscape may consequently alter species distributions and their patterns of abundance there.

3.3 Cumulative Effects

Assessing the impacts of a golf course on wildlife movements and habitat use is complicated by the plethora of variables involved. Often it is difficult to assess the impact of one entity, such as a golf course, on species that need to also be assessed at a landscape scale (Olson, pers. comm.). There may be secondary effects of varying intensity if the golf course is associated with other developments such as housing settlements, roads, clubhouses and hiking trails. Scientists believe that there is a maximum human threshold beyond which wildlife species cannot tolerate any further level of development or human presence (Olson, pers. comm.). A survey of carnivore movement in Jasper noted that carnivore displacement was directly correlated with an increase in human presence (Mercer et al., 2000).

The impacts of a golf course may vary widely depending upon its context. A golf course in a pure wilderness setting, i.e. Waterton, is more conducive to wildlife use and movement than a golf course which is surrounded by developments, i.e. Banff (Paquet, Watt, pers. comm.). Therefore, assessing how a golf course contributes to the cumulative effects of all human activity in an area must be kept in mind when evaluating the following information.

4.0 RESULTS

The fact that recreational activities have an impact on wildlife is appreciated but not well understood. Very few studies assess the impacts of popular forms of recreation upon wildlife and golf is no exception (Knight, 1995).

Very few surveys were found that assessed wildlife movements and habitat use prior to and post golf course development. Anecdotal data provided documentation on presence or absence of specific species on existing golf courses. Although this data provided important insights into the compatibility of golf courses and wildlife it did not reflect how patterns of wildlife movement might be altered by a golf course or if specific species or individuals may be displaced or attracted to the area over a long-term basis. Presence is not necessarily a sign of long-term species success in the area; it is only evidence of use (Paquet, pers. comm.).

Although this literature review has **not** been written for a specific golf course it has been designed to assist wildlife managers in assessing the impacts of golf courses on selected species in the Rocky Mountains. Therefore this literature review is most effectively used if the wildlife manager is knowledgeable in basic information with regards to individually proposed golf course developments. Such basic information includes:

- the location of the golf course development,
- the type of habitats altered due to the development (i.e. amount of forest lost),
- seasonal information on the development phase of the golf course,
- winter human activities associated with the golf course,
- a seasonal species inventory and awareness of endangered and threatened species, and
- the location of any associated developments, such as trails, roads, clubhouses and housing structures.

4.1 Documenting the Results

The results are documented on a per species basis. Each species section is composed of five subsections: research and observations, sensitivity to habitat alteration, sensitivity to human presence, the golf course as a movement corridor and a conclusion. The research and observation section lists surveys and anecdotal evidence of the species use or disuse of golf courses. The sensitivity to habitat alteration, human presence and movement sections provide background information on the general impacts of developments on wildlife habitat and movements. This information may be cautiously applied to golf courses. The conclusion attempts to summarize the potential impacts of golf courses on the species.

4.2 Golf Course Compatibility with Ungulate Species
4.2.1 Elk (*Cervus elaphus*)
4.2.1.1 Research and Observations

Research
There was only one quantitative study found that specifically addressed the effects of golf courses on elk habitat use and their movement corridors.

In Banff National Park, a large mammal winter monitoring program was established to determine the effects of human presence and development on wildlife corridors. The project was initiated in the 1993/94 winter season. (Duke, 1999). Numerous elk were recorded on the open fairways in the winter during all years of the monitoring program.

Observations
Numerous anecdotal observations provide insights to the relationship of elk and golf courses.

Elk may benefit nutritionally from the enhanced forage on the golf course, Monnello (pers. comm.) noted that golf course grasses have three times the nitrogen content and natural areas. A number of wildlife biologists have observed elk foraging on golf courses (Andre, Hillis, Hamlin, Spowart, pers. comm., Duke, 2000).

A wildlife review by Montana Fish, Wildlife and Parks assessed the potential impact of a proposed subdivision development with a golf course on winter ungulate range. The survey predicted one of two scenarios:

a) Elk could be displaced from the area due to human presence, placing pressure on other winter ranges where elk have caused problems for ranchers. A reduction in available wildlife habitat might result in increased stress, lower reproduction and survival rates.
b) Alternatively, elk might not be displaced, might become habituated and might continue to use the existing site, possibly leading to human-wildlife conflicts and management problems (Limke, pers. comm.).

Other observations provided evidence of both scenarios.

In Colorado, a monitoring program assessed elk use of an area before and after the development of a golf course/housing development. The golf course was developed on prime ungulate winter range. Prior to the golf course and associated housing development there were approximately 300-400 elk using the area for winter habitat. Researchers observed a reduction in the elk population eventually down to 50-60 elk. Elk were displaced from the area, resulting in migration to other winter ranges. The researchers attributed the displacement to the high level of human presence and settlement in the area. Although golf courses in other areas have attracted elk, the high level of human use in this area combined with local hunting (which deters habituation) caused displacement of some elk (Andre, pers. comm.).

In Alberta, elk on the Banff Springs Golf Course have taken up residency and are highly habituated. The elk have caused extensive damage to the golf course and have been known to chase people (Pattison, pers. comm.). Elk appear to have abandoned migration routes to exploit the golf course habitat which provides a year round supply of food and deters predators (Balagus, 1999). Habituation of elk has also been documented on other golf courses in Montana and Colorado (Limke, Spowart, Pattison, pers. comm.). The elk have damaged vegetation through trampling, browsing and rubbing antlers on trees (Limke, Davies, pers. comm.).

Elk are also attracted to the Kananaskis golf course for foraging. Their use of the golf course has resulted in indirect mortalities and management concerns. Hornung (pers. comm.) observed wolves running elk into fences, which were put up to protect the putting greens on the golf course. The elk would get tangled in the fences making them easy prey for wolves. Hornung (pers. comm.) also noted that the golf course may have been responsible for an increase in elk mortalities from vehicle collisions. Road access to the golf course and other recreational facilities nearby were improved and upgraded which resulted in an increase in wildlife deaths from vehicle collisions (Hornung, pers. comm.).

Typically, problem elk lead golf course managers and wildlife officials to take action. Reynolds (pers. comm.) is responsible for elk management issues in the Sunshine Coast region, B.C.. Elk were attracted to a golf course there and caused extensive damage particularly in the winter when the course was wet. The wildlife biologists translocated individuals from the area and have implemented a hunting program to reduce elk numbers on the course. Area managers have discussed the possibility of fencing in the golf course to permanently displace the elk.

In Montana, Hillis (pers. comm.) joined golf course design discussions on ways to ameliorate damage caused by elk. Suggested deterrence actions included fencing in the golf course, or planting grasses that were not palatable to elk (Hillis, pers. comm.). These initiatives would displace the elk from the enhanced golf course habitat.

4.2.1.2 Golf Courses as Habitat and Movement Corridors for Elk

There were numerous studies found that documented the effects of general habitat alteration and human presence on elk. These studies, combined with the numerous direct observations of elk on golf courses, highlighted the potential impacts and associated compatibility issues with golf course development in the Rocky Mountains.

Elk Sensitivity to Habitat Alteration

A golf course may change the landscape ecology of an area by converting forest patches to open space. An increase in open spaces may benefit elk by providing new foraging areas. In addition, grassland habitat on a golf course, whether it's natural or converted from forest, will be enhanced through intensive use of fertilizers and water. Elk are attracted to the enhanced forage on golf courses, provided there is a sufficient amount of cover for protection (Andre, pers. comm.). The enhanced forage and increased foraging area provided by a golf course may be particularly important in the spring and winter when elk are in their absolute lowest physical condition. The importance of spring range in ensuring recovery from winter weight loss is well documented (Canfield et al., 1999). Until new, green forage restores lost weight and energy, these animals may succumb to stresses that would be considered minor at other times of the year. A loss of winter and spring foraging areas may have a significant negative impact on these animals (Canfield et al., 1999). A golf course will physically provide an increase in winter and spring foraging habitat but the ability of elk to use the habitat will depend upon elk and human interactions.

Elk Sensitivity to Human Presence
An elk's sensitivity to human presence depends on the elk's previous exposure to humans, especially if the population has been hunted. A golf course will increase the human presence in an area during the golfing season and may improve human access during other seasons.

Nonhabituated elk, particularly from hunted populations, are more likely to be initially displaced from a golf course, as the level of humans increases. A study by Axys Environment on the Eagle Terrace Development in Canmore, Alberta, documented wildlife movement in a natural area adjacent to human settlement. Elk use of the area reduced over time as human and domestic dog numbers recreating in the area increased (Balagus, 1999). A study in Southwestern Alberta for a proposed ski hill expansion assessed the impact of an increase in human presence on a hunted elk population. The study found that there was a significant decline in the elk population during the initial years of human increase. Elk use of the site was positively correlated with the lowest periods of human activity. Although the elk population has increased each year since the initial development, it has not reached previous numbers (Morrison et al., 1995).

If elk are displaced, the significance depends upon the season. Elk are more sensitive to displacement during the winter or spring (calving) season. Dr. Allredge assessed the impact of human disturbance on elk during the calving season by surveying a treatment and control area of 150 sq. miles in the remote wilderness. Approximately seventy calves were born in each of the areas before the survey was initiated. For one month during the calving season, eight humans walked through the treatment survey area and disturbed the elk. Humans continued to walk toward the elk until the elk fled. The number of calves born in the treatment area was reduced to 40 individuals after three seasons, while the calves in the control area increased to 72. The study concluded that the reproductive capacity of nonhabituated elk is negatively correlated with human disturbance (Andre, pers. comm.).

Elk, particularly non-hunted populations, may adjust to human presence (habituation) as an adaptive strategy, promoted by the need to conserve energy, out-compete other individuals and find unused resources (Thompson and Henderson, 1998). A winter study in Yellowstone National Park suggested that elk are less sensitive to humans as exposure grows. The study indicated that in more developed areas, elk moved away from humans at distances of 15 m compared with elk in remote areas of the park, which moved away at distances of 400 m (Cassirer et al., 1992). The elk on the Banff Springs Golf Course in Alberta are very habituated and remain on the golf course during the golfing season to take advantage of the enhanced forage (Pattison, pers.comm.). Of course, although elk are easily habituated, hunting and other aversive techniques (translocation, fencing, planting unpalatable grasses) may limit the level of habituation (Limke, pers. comm.).

Displacing elk from a golf course, whether it is due to elk intolerance of humans or through aversive conditioning of habituated elk, reduces the habitat effectiveness of the area. This will be significant to the elk if the golf course is developed on prime winter habitat and the elk are displaced in the winter or spring when they are the most vulnerable.

Golf Courses as Movement Corridors for Elk

If a golf course is to function as an effective travel route one must consider the level of human presence and the habituation level of the elk. These factors will act as a gradient upon which the golf course will act as a barrier, filter or as a travel corridor for elk. For a hunted elk population, which is unlikely to become habituated, the golf course, during the golfing seasons and other peak periods of human activity, may act as a barrier to movement. Tolerant elk may use the golf course as a travel route. Finally, elk populations that are not hunted are more likely to become habituated. For habituated elk, a golf course may disrupt natural migration routes by offering a year round supply of forage (Monnello, pers. comm.).

4.2.1.3 Conclusion

The effect of a golf course on elk depends upon the habituation of elk, the level and seasonality of human presence and the level of human tolerance for elk on the course. Regardless of habitat potential and an elk's habituation, if humans remove elk from the course, its habitat effectiveness is compromised.

A golf course affects elk by improving their habitat, by increasing human presence in the area and by changing its potential to act as a movement corridor. A golf course's enhanced grassland will improve its attractiveness to elk. An elk's ability to use this enhanced habitat will depend upon its level of habituation. An elk from a hunted population is more likely to be initially displaced by the course's increase in human presence. Non-hunted elk are more likely to adjust to human presence and become habituated. In general, elk become less sensitive to humans as exposure grows. If elk become habituated, they may cause extensive damage to golf courses, raise safety concerns, and upset predator-prey dynamics (Pattison, Olson, pers. comm.). Aversive management techniques ultimately lead to the displacement of elk from the golf course and, therefore, to a reduction in its habitat effectiveness. Such displacement is significant to an elk if it occurs during winter or early spring, when an elk is most vulnerable. The use of a golf course as a movement corridor will also vary depending upon the elk's previous exposure to humans and level of habituation. Some elk, particularly from non-hunted populations, may use a golf course as a travel corridor during periods of low human use. If an elk becomes highly habituated it may stay permanently on a golf course to forage, disrupting its natural migration route. Alternatively elk from hunted populations are more likely to avoid golf courses as movement corridors.

The effect of a golf course on an elk population will also depend upon the context of the golf course. A golf course with other associated developments will have less travel route options and escape routes than a wilderness course. In addition there will be more humans in the area, increasing the opportunity for human-elk conflicts and the likelihood of elk displacement. Finally, the disruption of predator-prey relationships will likely magnify if golf courses exist in association with other human developments.

4.2.2 Mule Deer (*Odocoileus hemionus*) and White-Tailed Deer (*Odocoileus virginianus*)

4.2.2.1 Research and Observations

Research

The effects of a golf course on deer habitat use and movement were addressed in two quantitative studies.

In Colorado, a study found there was an increase in the carrying capacity of ungulates on golf courses relative to natural areas. The application of water and fertilizers increased the nutrition of forage (Andre, pers. comm.).

The large mammal winter monitoring program in Banff National Park (see elk, above) rarely observed deer on the golf course. (Duke, 1999). They were more commonly found in the covered areas adjacent to the golf course. (Duke, 1999, Stevens & Owchar, 1997 and Heuer et al., 1998).

Observations
The following anecdotal observations provide understanding into the relationship of deer habitat use and movement on golf courses.

Numerous wildlife biologists noted that deer are attracted to golf courses to forage (Andre, Hillis, Hamlin, pers. comm.). Deer are observed occasionally on golf courses in Estes Park, Colorado, Lolo National Forest, Montana and in Revelstoke and Kamloops, B.C. (Czarnowski, Jury, Hillis, pers. comm.). Deer use the golf course in Waterton Lakes National Park, mostly when it is closed, for foraging and bedding areas (Watt, pers. comm.).

Davies (pers. comm.), a wildlife biologist, reported numerous issues regarding deer on the Air Force Golf Course in Colorado. Deer damage the course by trampling and browsing upon vegetation. Davies estimates damage at $10,000-15,000 US per year. A hunting program was initiated to reduce numbers and damage to the golf course (Davies, pers. comm.).

Alternatively, Waite (pres. comm.), a biologist from Colorado, observed a decrease in the deer population after a golf course development. He attributed the decrease to a lack of cover on the golf course.

4.2.2.2 Golf Courses as Habitat and Movement Corridors for Deer
The general sensitivity of deer to human presence and habitat alteration is documented to provide insights into the use of the golf course as habitat and as a movement corridor.

Deer Sensitivity to Habitat Alteration
A golf course will convert forest to open space, providing new forage habitat. In addition, the grassland habitat on a golf course will be enhanced through fertilizer and water application. A deer will be attracted to the new and enhanced forage provided by a golf course if there is sufficient cover for security. Several studies have documented the attraction of deer to improved availability of palatable plants along linear disturbances (Loft & Menke, 1984). A golf course may provide important spring foraging opportunities, which assure recovery from winter weight loss (Canfield et al., 1999). During this time deer may succumb to stresses considered minor at other times of the year. A loss of winter and spring foraging areas may have a significant negative impact on these animals. A golf course will provide deer with enhanced foraging habitat during periods of vulnerability if there is a sufficient amount of cover provided for security (Lyon and Jensen, 1980).

Deer Sensitivity to Human Presence

The ability of deer to use the golf course as habitat will depend upon the level of human presence in the area and upon the deer's level of habituation. Studies have documented that deer may be displaced from preferred habitat due to linear developments associated with an increase in humans (Freddy et al, 1986). Human presence will have varying degrees of impact, depending upon whether the deer population has been previously hunted. A hunted deer population is more sensitive to human presence than non-hunted populations (Behrend, 1968). Populations that are not hunted are more likely to become habituated and use the golf course as preferred habitat. Once habituated to urban environments, deer populations are difficult to control and aversive conditioning is often employed to remove deer from the region. For example, in Colorado, habituated deer caused extensive damage to a golf course and a hunting program was introduced to reduce the number of deer in the area (Davies, pers. comm.). Removal of deer from the area is significant if they are displaced from prime winter or spring habitat when they are the most vulnerable. In addition, a golf course may attract tolerant predators to the prey base. In both Colorado and Montana, habituated white-tailed deer have attracted cougars to the edge of housing developments, thereby increasing the risk to humans and their pets as well as the cougar (Canfield et al, 1999). Conversely, a golf course may protect deer from predators that are intolerant of human activities.

The context of the golf course is important in assessing the use of a region by deer. A golf course in a developed environment is more likely to displace deer than a course unassociated with developments. Vogel (1983) found that there is an inverse relationship between housing density and the number of deer observed. Deer were displaced when there were over 4-8 houses per km^2. Human disturbance changes the number of deer in a population, alters the time of day and season that deer will use the area and alters their population dynamics. Vogel documented that white-tailed deer inhabiting developed areas were more nocturnal and secretive and made greater use of cover during the day.

Golf Courses as Movement Corridors for Deer

For a golf course to function as a travel corridor, there must be sufficient cover. Cover provides places for escape from predators, protection against winter extremes and is a source of shade (Leege, 1984). Deer rarely travel across broad expanses of open area without access to cover (Leege, 1984). The need for cover rises when there is an increase in human presence and the deer, therefore, require additional security from humans. Vogel (1983) and Hayden (1975) found that deer from a diminished population still used forested areas as travel routes near housing developments. Alternatively, Waite (pers. comm.) noted a decrease in the use of a golf course by deer, which he attributed to a lack of cover.

4.2.2.3 Conclusion

The effect of a golf course on deer depends upon the habituation level of the deer, the level and seasonality of human presence and the amount of cover available. If deer are displaced through habitat avoidance, through aversive conditioning, or through hunting, the habitat effectiveness of a golf course is compromised.

A golf course affects deer by offering new and enhanced foraging habitat, by increasing human use and access and by shifting their temporal use and movement through an area. A golf course may attract deer by offering new and enhanced foraging habitat provided there is a sufficient amount of cover for hiding. The use of the golf course by deer will depend upon the level of human presence. Some individuals, especially from hunted populations, will likely be displaced. In other cases deer may become habituated. Habituated deer may cause extensive damage to trees and vegetation on a golf course and management action may have to be taken to deter or reduce the population (Czarnowski, Jury, Hillis, Davies, Andre, pers. comm.). Displacement reduces the habitat effectiveness of a golf course, which may have especially negative consequences if it occurs in the winter or spring when deer are most vulnerable. A deer's use of a golf course as a movement corridor is dependent upon the amount of cover available. Studies have found that deer will travel though a connected forest corridor, even in areas of human development.

The effect of a golf course on a deer population will also depend upon the context of the golf course. A golf course associated with housing settlements and other human developments is more likely to displace deer from the area. In addition, deer are more sensitive to the amount of cover offered by a golf course if it is associated with human developments. A golf course in a matrix of development will have less travel route options available for movement and escape. As a result, a golf course surrounded by human developments will have a greater impact on predator-prey relationships than a wilderness golf course, which will likely have more habitat and travel options available.

4.2.3 Bighorn Sheep *(Ovis canadensis)*

4.2.3.1 Research and Observations

Research

Two quantitative studies were found that documented the effects of golf courses on bighorn sheep. The studies provided insights into the use of a golf course as bighorn sheep habitat and/or as a movement corridor.

Three Sisters Resort Properties evaluated the impact of the Stewart Creek Golf Course on bighorn sheep access to a mineral lick. The survey took place in 1997-1998, nearing the completion of golf course construction. During this two-year period the sheep continued to use the mineral lick, however the number of sheep appeared to have decreased slightly in comparison to historical records. The decrease may have been due to either natural population fluctuations or to the added increase in human disturbance. Track pad monitoring indicated a slightly greater use of trails in undisturbed areas (200 m from the mineral lick and in a nearby wildlife corridor) than on the golf course fairways. To encourage continued access to the mineral lick the developers have maintained 100-200 m of tree cover near the mineral lick to ensure escape routes and limit viewing of the area by humans (Harris, 1999).

In Banff National Park, the large mammal winter monitoring program (see elk, above) recorded sheep on the golf course during its 1997/98 season (Duke, 1999). Sheep were recorded primarily against the cliffs of Rundle Mountain and at the base of the cliffs on Tunnel Mountain, as opposed to on the open fairways (Heuer et al., 1998).

Observations
Anecdotal observations were recorded for the use of golf courses by bighorn sheep as habitat and movement corridors.

Osprey Communications, in Radium, British Columbia, initiated a program in 1997 called Bighorn in our Backyard (BIOB). The BIOB Project seeks to highlight the needs of wild bighorn sheep in the Radium area and bring to light the unique challenges and opportunities that this human-wildlife relationship presents. Osprey Communications observed bighorn using a golf course in the winter. Unpublished data indicated that the normal migration pattern of bighorn changed over the past 8-9 years. This was attributed, in part, to the presence of the golf course coupled with other human/ecological factors (Swan, pers. comm.).

Watt (pers. comm.) noted that bighorn sheep do not frequent the Waterton Lakes Golf Course, although they are commonly found in and around the townsite. Despite the enhanced forage available on the golf course the golf course does not offer escape routes and is therefore avoided by habituated bighorn sheep.

4.2.3.2 Golf Courses as Habitat and Movement Corridors for Bighorn Sheep
Studies were found that documented the effects of general habitat alteration and human presence on bighorn sheep. Combined with Rocky Mountain research on golf courses, they provide insight into potential bighorn use of these as habitat and movement corridors.

Bighorn Sheep Sensitivity to Habitat Alteration
Key habitat areas for bighorn sheep include lambing grounds, escape routes, mineral licks and grassy winter/spring range free of snow cover (Canfield et al., 1999). If a golf course is nearby, bighorn sheep need continued access to such habitats if they are to persist.

A golf course’s additional and improved forage will generally result in improved habitat potential for bighorn sheep. A golf course will change the landscape ecology of an area by converting forest to open habitat. Furthermore, the grasslands on a golf course will be enhanced with fertilizers and water. This extended and improved range may attract bighorn sheep (McLellan, pers. comm.). Morgantini and Mead (1990) documented that bighorn sheep were attracted to oil and gas well sites for the palatable grasses, which were planted to help prevent erosion. Visibility is a potentially important characteristic of all components of bighorn habitat for detection and communication of danger among individuals (McCarty & Bailey, 1994). They prefer to be out in the open and seldom travel greater than 100 m through the woods (Gadd, 1995). Morgantini and Burns (1988) indicated that enhanced forage along linear developments (seismic lines) were often in a matrix of forested areas, which increases the risk of predation. As with deer and elk, bighorn sheep may be attracted to enhanced forage on narrow fairways and may either be at increased risk from habituated predators or reduced risk from non habituated predators. Either way, the predator-prey dynamics of the system may change.

Bighorn Sheep Sensitivity to Human Presence
Bighorn sheep have shown varying degrees of tolerance to an increase in human presence, depending upon their level of habituation (Horejsi, 1976). A golf course will increase human

presence in the area during the golfing season and may also increase human access to the area throughout the year.

Bighorn sheep may exhibit outward signs of stress from human presence. During the first year of operation of the Nakiska Ski Hill, bighorn sheep temporarily abandoned prime winter habitat. This was attributed to helicopter presence, an increase in human presence on the ridge and avalanche blasting (Jorgenson, 1988). Individuals that are not tolerant of humans may be temporarily displaced from the golf course. Other individuals may not abandon the habitat completely but avoid the area when people are present by shifting their activity patterns (Canfield et al, 1999). In both cases, this reduces habitat effectiveness, as the sheeps' access is either limited or altered.

Alternatively, there is also documentation of individuals exhibiting few outward signs of stress from human disturbance. An oil well construction site in Southwestern Alberta had little impact on the local sheep herd. They were observed grazing 20 m from a road and well site development while construction was underway (Morgantini, 1991). In addition, habituated sheep frequent the Waterton townsite, particularly the open school field (Watt, pers. comm.). Habituated individuals may use a golf course as habitat.

MacArthur et al. (1982) noted that the apparent level of human tolerance may be misleading. They assessed the heart rate of bighorns near humans and found that the appearance of a human within 50 m of a sheep resulted in a 20% rise in heart rate. The rise in heart rate was not evident from behavioral clues. A few disturbance events may not be significant but the cumulative effect may have implications on the long-term health of a population.

There may also be long-term consequences to habituation. For example, individuals may be more susceptible to hunting or the spread of diseases. A large numbers of bighorn sheep congregating in an area increase the possibility of spreading diseases and infestations of parasites (Alberta Natural Resources Conservation Board, 1992). A study in west-central Alberta found lambs had contracted contagious ecthyma, from licking salt off the roads. Sheep congregated and spread the disease (Morgantini & Burns, 1988). Sheep will congregate when they are in a stressful situation or where there is an abundance of forage. A golf course may provide both situations.

In summary, a golf course may result in an initial decline in habitat for bighorn sheep until a level of tolerance has been developed. This is significant if the area represents prime winter habitat or is near mineral licks or lambing areas. These areas should be maintained with minimal development and human activities to ensure long-term survival of the bighorn sheep in the area. For example, according to expert opinion and professional judgement in B.C., human viewing areas and trails should be at east 300 m from mineral licks (Harper, pers. comm.).

Golf Course as Movement Corridors for Bighorn Sheep

For a golf course to function as a movement corridor for bighorn sheep, one must consider the level of human use and the location of associated developments such as roads and building facilities. The level of humans in the area and the individualistic response of the animal will determine the success of the golf course as a movement corridor for bighorn sheep. The golf course may act as a barrier to movement for intolerant individuals, as a movement filter, or as a travel corridor for tolerant sheep. In addition, a sheep's level of tolerance may shift over time as they adjust to an increase in human presence. Evidence does suggest that bighorn sheep require escape routes and corridor access to their sensitive habitats. These areas should remain free of developments and low in human activity to ensure use by all individuals.

4.2.3.3 Conclusions

The effects of a golf course on a bighorn sheep will depend upon the level of human presence in the area, the sheep's level of habituation, and the displacement of sheep from sensitive habitats. Generally, sheep may exhibit some initial displacement, which is significant if they are removed or prevented access to mineral licks, escape routes and/or lambing areas.

A golf course affects sheep by enhancing habitat, increasing human presence and disrupting movement patterns. Sheep may be attracted to the enhanced foraging habitat offered by a golf course. The ability of bighorn sheep to use the enhanced habitat will depend upon the sheep's tolerance to humans and vice-versa. Some sheep will likely be displaced, others will likely shift their temporal patterns and some will likely use the golf course as habitat. A sheep population with little previous human exposure might be initially displaced. This displacement is particularly problematic if they are prevented from using mineral licks, escape routes, or lambing areas on or near the course. However, in general, sheep will be attracted to enhanced forage and can become tolerant of human activities. Again, as with elk or deer, sheep may become attracted to golf courses and linger, rather than moving through them. This movement dysfunction may be compounded if associated developments also block corridor access to other sensitive habitats.

4.3 Golf Course Compatibility with Carnivore Species

4.3.1 Grizzly Bear (*Ursus arctos*)

4.3.1.1 Research and Observations

Research

There were no quantitative studies found that specifically addressed the effects of golf courses on grizzly bears as they relate to habitat use or movement corridors.

Observations

There were numerous anecdotal observations recorded, however, that provided insights into the relationship between grizzly bears and golf courses.

The Montana Division of Wildlife tracked four radio-collared grizzly bears on two golf courses. One golf course was associated with a low level of human development (twenty housing units and twenty condos). The other course had just been built and at the time had no associated housing developments. The bears were attracted to the golf courses in the early spring to forage on green grasses at a time, which also coincided with a period of low human presence. Some of the bears were observed digging for ground squirrels. The bear activity occurred primarily prior to the golfing season except for one adult female that returned to the golf course in the fall to forage on berries. She shifted to foraging after dark and to sleeping in a 75 m^2 forested patch during the day. Unfortunately, of the bears observed above, one was shot near the golf course by a hunter who had misidentified it as a black bear. The female, which had returned for berry season, eventually had to be translocated from the area. The other bears left the area before the golfing season started (Manley, Weneum, pers. comm.).

Other area biologists in Montana have also reported grizzly bears frequenting golf courses to forage on grasses in the early spring and to eat berries in the fall (Coates, Carney, pers. comm.). Carney (pers. comm.) has had to use aversive conditioning techniques to discourage grizzly bears from using a golf course when golfers were present.

In Alberta, Hornung (pers. comm.), a Conservation Officer since 1991, occasionally observed grizzly bears using the Kananaskis golf course as a travel route. The golf course was built along a valley bottom, on the edge of a river, a natural travel route for most wildlife. Only 35 of 9000 telemetry locations, based on 56 bears in the Kananaskis region, were recorded on or near the golf course. For the three bears living in the area, 2-4% of the telemetry points occurred near the golf course. The data implies that grizzly bears circumnavigated the golf course, even though it is located along a riparian travel route (Gibeau, pers. comm.). This golf course is essentially a wilderness golf course with no residential development associated with it, however, there are 3 hotels located within 3 kms. During the survey, one grizzly had to be translocated off the golf course for human safety concerns and another was killed in a vehicle collision. Road access to the golf course and other recreational facilities nearby was improved and upgraded which has resulted in an increase in wildlife deaths from vehicle collisions (Hornung, pers. comm.).

Elsewhere in Alberta, grizzly bears have been observed on golf courses foraging or just moving through the area. Since construction of Three Sisters Resorts Stewart Creek Golf Course in Canmore, one or two incidences a year have been reported of grizzly bears, including sows with cubs, being observed on the course. Some of these have resulted in the course being closed for short periods of time (Jorgenson, pers. comm.). Pattison (pers. comm.), observed a grizzly bear moving quickly through the Banff Springs Golf Course.

There is some anecdotal evidence of grizzly bears being displaced from golf courses. Grizzly bears are rarely seen on golf courses in the Rocky Mountain Trench of British Columbia despite a very high grizzly bear population inhabiting the area. Forbes (pers. comm.) believes this avoidance of golf courses is due to both a high human presence in the area and a general lack of food. Grizzly bears are also rarely observed on the Waterton Lakes Golf Course, despite a large local population. They seem to prefer an adjacent covered trail, possibly because of increased human presence in the area (Watt, pers. comm.).

4.3.1.2 Golf Courses as Habitat and Movement Corridors for Grizzly Bears

Numerous studies were found that documented the effects of general habitat alteration and human presence on grizzly bears. These studies, combined with direct observations of grizzly bears around golf courses, highlighted the potential impacts and associated compatibility issues with golf course development in the Rocky Mountains.

Grizzly Bear Sensitivity to Habitat Alteration

Grizzly bears require habitats that provide a local abundance and sequential availability of foods (Witmer et al, 1998). Open areas for foraging should be interspersed with forest cover needed for security and bedding and these must both be relatively free from human disturbance (IGBC, 1987). A study in Yellowstone National Park noted that grizzly bears constructed beds in dense tree cover with visibility less than 10 m. (Blanchard, 1980). A study by Graham (1978) reported all sightings of grizzly bear occurred within a 50 m distance of cover.

A golf course will change the landscape ecology of an area by altering the forest structure: enhancing artificial grasslands while removing trees. This change in vegetation composition and community patterns results in altered habitat patches and movement corridors. Grizzly bears may use these altered habitats provided the necessary life requirements for food, shelter and security are available. The changes in the landscape by a golf course may actually enhance habitat for grizzly bears in the spring by providing nutritious grasses. Conversely, golf courses may reduce habitat by removing sufficient cover for hiding.

Golf courses located in habitats or landscape locations which bears are already predisposed to using will have disproportionately greater impacts. If grizzlies are funneled by landscape pattern into places like riparian areas, major valley confluences and narrow valleys in mountainous terrains, they will be particularly affected when these places are altered (Van Tighem, pers. comm.).

Grizzly Bear Sensitivity to Human Presence

A significant issue for grizzly bears and golf courses is the increase in human presence and associated human developments (Weneum, pers. comm.). Although there is no clear threshold on how many humans a grizzly bear will tolerate, a study in Yellowstone National Park found that grizzly bears reacted behaviorally when there are over 20 human events per week. An event represented a group of 2 to 3 people (Mattson, 1992). Furthermore, a study in Jasper found a direct correlation between an increase in human presence and a decrease in carnivore use (Mercer et al., 2000). The amount of development and the number of humans in and around the golf course will significantly impact its value as wildlife habitat and as a movement corridor.

The response of grizzly bears to golf courses appears to be highly individualistic (Manley, pers. comm.). In fact, bear researchers reported that, in general, grizzly bears vary highly between individuals in their behavior (Stirling & Derochier, 1990). Bear tolerance to humans follows a gradient based upon their response to food availability and the age, sex, and past experiences of each bear (Gibeau, 2000, Mattson, pers. comm.). Grizzlies, therefore, will likely respond in varied ways to golf courses. Grizzly bears that are more sensitive to human activities will be more prone to exhibit habitat avoidance, thereby reducing the habitat effectiveness of the area for certain bears. Habitat avoidance tends to be seasonal depending on the individual bear and human presence in the area.

Other grizzly bears may undertake short-term temporal avoidance. A bear may shift from diurnal to nocturnal foraging activities to access resources and avoid contact with humans. Gibeau (2000) found that high quality habitats near town sites and recreational developments were substantially underused, especially during the day. Grizzlies were more likely to take advantage of high quality habitats near developments when humans were less active. No studies were found that documented the long-term impacts of such shifts in temporal foraging patterns on community dynamics (e.g. interspecific competition).

Individual bears that are more tolerant of humans are more likely to use resources close to human developments but, as a result, are more prone to becoming habituated. Mattson (pers. comm.) emphasizes that during periods of natural habitat decline, such as during poor berry years, non habituated grizzly bears may also become attracted to golf courses for feeding opportunities. These bears may then become tolerant of humans and some may return in the future. Habituation has a potential short-term benefit in enabling access to resources that non habituated bears would normally avoid. Although habituation may benefit certain individuals in the short term, the long-term result is an increase in human-bear interactions. (U.S. Fish and Wildlife Service, 1993). As a result, habituated bears may become more vulnerable to hunters, management controls (death/translocation), and road collisions with vehicles. A study by Mattson et al. (1996) reported that 68% of grizzly mortalities in the Greater Yellowstone Ecosystem occurred in human impacted areas that represented 33% of grizzly bear habitat. Many other bear researchers have reported that humans are the leading cause of death to grizzly bears (Jope, 1985, Craighead et al, 1988, Mattson, 1998). Mattson (1992) found that habituated females are 3.8 times more likely to die at the hands of humans than wary bears. Generally, habituation leads to direct or indirect mortality and should be avoided (Claar et al., 1999).

To discourage habituation of grizzly bears, aversive conditioning has been used in Montana and Alberta to remove bears from the golf courses during the golfing season. Removing and displacing bears from golf courses obviously reduces habitat effectiveness of an area (Carney, pers. comm.). If this area is designated as a wildlife habitat patch or corridor such displacement runs counter to the intended use of the area.

Golf Courses as Movement Corridors for Grizzly Bears

Defining the shape and the minimum length, width and amount of cover of a corridor for grizzly bears is complicated and depends upon a number of variables. These variables include ease of travel, location on the landscape, habitat quality of end patches and edges, and the level of human development and use associated with the corridor (Beier, 1993, McLellan, 1990). The effectiveness of a golf course functioning as a travel corridor for grizzly bears depends upon the amount of cover, the location and number of obstructions manifested by human development, and the human use of the golf course lands.

Cover is an important feature if a golf course is to function as a wildlife corridor. Hiding cover is important in deterring human-bear conflicts. Grizzly bears tend to run toward cover when fleeing from human presence (Mattson, 1993). In addition flight from humans is less likely when the bear is in cover than in the open. (Mattson et al., 1996).

In addition, the ability of an area to function as a wildlife corridor will significantly decrease if the area becomes an obstruction to movement rather than a thoroughfare. Aside from physical obstructions, such as roads and large fences, golf courses can pose as virtual obstructions if bears loiter in the area rather than passing through. Bears may stay around a golf course if there are human attractants such as dog food, birdseed and garbage in the area (Manley, pers. comm.). Bears that become habituated to these areas frequently end up in conflicts with humans (Claar et al., 1999). In these cases, an intended corridor may become a movement sink.

A report by Banff National Park (1992) recommended that, to reduce the ecological and management costs of human-wildlife conflicts, wildlife corridors be sustained. Heuer (1995) pointed out that this recommendation be implemented by limiting the human development around critical wildlife corridors. If additional development were to be placed *within* a wildlife corridor it could introduce additional ecological and management costs that the corridor was intended originally to alleviate.

4.3.1.3 Conclusion

The effect of a golf course on a grizzly bear will primarily depend upon the level of human presence, the individual bear's personality, the site development and its context. Regardless of the bear's tolerance level, as human presence increases, a grizzly bear will likely be displaced either immediately (if non habituated) or over the long–term through human intolerance (if habituated). The threshold will depend upon human tolerance (Hornung, pers. comm.).

Golf courses affect grizzly bears by altering their habitat, by increasing human presence in the area and, possibly, by shifting travel patterns. A bear may seek out the improved forage in the spring particularly if there is hiding cover and a low level of human presence (Hornung, Weneum, Manley, pers. comm.) but as human presence increases through the season, a bear will become increasingly susceptible to either natural displacement or management action. A bear might use the area as a travel corridor if there is sufficient security cover. If the golf course becomes an obstruction due to physical developments and/or human attractants that lead to habituation, then the movement corridor will be compromised (Manley, pers. comm.). The likely result of habituation will be the bear's displacement or direct/indirect mortality (Jope, 1985; Craighead et al, 1988; Mattson, 1998).

It is difficult to qualify the impacts of a single development, such as a golf course, on an entire grizzly bear population due to their large home ranges and variable sensitivity to human pressures. A golf course should be assessed in accumulation with other regional developments. The context of the golf course, therefore, is an important factor in assessing its effects on a grizzly population (Paquet, Watt, pers. comm.).

A grizzly bear population needs secure habitat patches and wildlife corridors if it is to persist (Gibeau, 2000). In a matrix of development and other inhospitable habitat, a grizzly population needs undeveloped patches and movement routes to be specified and maintained (Paquet, pers. comm.). A golf course may compromise these habitat patches because grizzly bears may be displaced from golf courses associated with high levels of human presence. A golf course in these areas must be complemented by, and cannot replace, a movement corridor for grizzly bears. In a matrix of wilderness, with less human developments, a grizzly population has more habitat and movement options and a golf course will have less of a cumulative impact on the population[1].

[1] Of course, developing a golf course in an area where there is no human development may have a greater impact on a grizzly bear population than a golf course in an urban area. A completely new development would increase human access into a wilderness area and may act as a kernel for further development (Van Tighem, pers. comm.).

4.3.2 Black Bear *(Ursus americanus)*
4.3.2.1 Research and Observations

Research
Two quantitative studies were found that provided knowledge on the relationship of black bears and golf courses. Each surveyed black bear use of the golf course as habitat or as a movement corridor.

A study from 1988-1992 involving radio-collared black bears living around the Banff Townsite indicated that the Banff Springs Golf Course was a common travel route (Heuer,1995).

Conversely, a study in Riding Mountain National Park compared the use of an area prior to and post golf course development and found that black bears had used the golf course less than expected (Paquet, pers. comm.). Although black bears continued to use the golf course, their preference for the area had diminished.

Observations
The following anecdotal observations contribute to our understanding of the relationship between black bears and golf courses.

In Alberta, Saskatchewan and Manitoba, black bears have been observed on golf courses in Kananaskis Country, Prince Albert National Park and Riding Mountain National Park (Paquet, pres. comm.). Pattison (pers. comm.) has observed black bears on the Banff Springs Golf Course during the golfing season.

In Montana, black bears have commonly been found feeding on berries on golf courses. Aversive conditioning techniques have commonly been used to displace them (Weneum, Carney, pers. comm.).

In Colorado, Waite (pers. comm.) regularly observed black bears on a golf course. The golf course was surrounded by housing developments and the bears were often victims of human-bear conflicts. Conflicts occurred throughout the development-as-a-whole, not the golf course in particular. Similarly, Andre (pers. comm.) noted that black bears have commonly travelled through the golf course in Vale. Problems have arisen as housing developments increased around with the golf course.

4.3.2.2 Golf Courses as Habitat and Movement Corridors for Black Bear
Studies addressing black bears' sensitivity to habitat alteration and human presence were evaluated. These studies, in conjunction with observations of black bears on golf courses, provided clarity on the potential impacts of a course development in the Rocky Mountains.

Black Bear Sensitivity to Habitat Alteration
A golf course's mixture of enhanced grassland and forest habitat will provide black bears with a variety of foraging opportunities. A golf course will change the landscape ecology of an area by converting forest to open space, and by changing the predator/prey dynamics. Black bears use a variety of habitats but prefer a mix of forested and open areas, which produce a high degree of edge and diversity of vegetation (Riddell Environmental Research & Axys Environmental

Consulting, 1987). Black bears may use altered habitats provided there is sufficient cover available. The changes of the landscape by a golf course may, therefore, enhance habitat for black bears by attracting prey species, offering enhanced forage, and by increasing the edge and open space (Alberta Natural Resources Conservation Board, 1992).

Black Bear Sensitivity to Human Presence

Black bears are not as sensitive to an increase in human presence as grizzly bears but are susceptible to human intolerance of bear–human conflicts. A study of the Three Valley Confluence region in Jasper National Park found a direct correlation between an increase in human presence and a decrease in carnivore use (Mercer et al., 2000). Black bears, however, were the most common large carnivore detected in the study area. Thirty-six were observed in 1999, compared with three grizzly bears and zero wolves. Black bears were the only species, other than coyote, that were observed in the study area below 1100m in elevation (Mercer et al., 2000).

A black bear is fairly adaptable and can accommodate some increase in human activity within its home range by becoming habituated. Humans, however, are generally intolerant of black bears once the bears have become habituated. Wildlife officers may use aversive conditioning techniques to displace the bear, they may translocate the bear away from the area or they may terminate the animal if it is deemed incorrigible. In many cases, habituation is often an early death sentence for a bear (Claar et al, 1999). Therefore, the level of human presence on the golf course and the level of human tolerance toward bears will determine a bear's success in using a golf course as habitat.

Golf Courses as Movement Corridors for Black Bear

If a golf course is to function as an effective movement corridor, it must maintain sufficient cover, humans must tolerate the passage of bears, and bears must not be enticed to linger by the presence of attractants. Cover is important as it provides security and is important in deterring human-bear conflicts. Humans must generally tolerate the presence of bears on fairways and in wooded areas along the course. Finally, the course must not become either a physical or virtual obstruction to movement. Aside from physical obstructions, such as roads and large fences, golf courses can obstruct movement if bears are attracted to the area rather than moving through. Bears will stay around a golf course if there are human-based attractants available such as dog food, birdseed and garbage (Manley, pers. comm.). If bears become habituated to such attractants, an intended corridor may become a movement and, potentially, a mortality sink.

4.3.2.3 Conclusion

The effect of a golf course on a black bear depends largely upon how humans handle bear response to potentially improved habitat. Black bears can adjust to moderate levels of human activity but are often not tolerated by humans, resulting in translocation or removal of the bear from the population.

A golf course may affect black bears by both improving habitat and increasing human presence in the area. A bear may seek out the improved forage in the spring particularly if there is hiding cover and a low level of human presence (Hornung, Weneum, Manley, pers. comm.). Although a black bear will be more likely to adjust to an increase in human presence than a grizzly bear, as human presence increases through the season, a bear is more likely to become displaced either naturally or through management action. The end result of habituation most likely will be the bear's displacement or direct/indirect mortality due to human intolerance (Jope, 1985, Craighead et al, 1988, Mattson, 1998).

A bear might use the area as a travel corridor if there is sufficient cover for security. If the golf course becomes an obstruction due to physical developments and/or human attractants that lead to habituation, then the movement corridor is compromised (Manley, pers. comm.).

A golf course should be assessed in accumulation with other regional developments. The context of the course is an important factor in assessing its effects on a bear population (Paquet, Watt, pers. comm.). A golf course in a heavily developed area will have less habitat and movement options for a black bear than a wilderness golf course. It is likely that golf courses associated with developments will have a greater impact on a black bear population than a wilderness golf course. Conversely, the introduction of a golf course to a wilderness setting may precipitate other developments which would, as a whole, compromise secure habitat for a black bear. In other words, both cumulative AND potential 'downstream' impacts should be evaluated when assessing the impacts of a golf course on black bears (and other wildlife).

4.3.3 Wolverine (*Gulo gulo*)

4.3.3.1 Research and Observations

Research

Only one quantitative study was found that addressed the effects of golf courses on wolverine habitat use and movement.

The large mammal winter monitoring program in Banff National Park (see elk above) has not recorded wolverine during seven years of surveys (Duke, 1999).

Observations

There were no anecdotal observations recorded.

4.3.3.2 Golf Courses as Habitat and Movement Corridors for Wolverine

Very little is known about the wolverine, but a few studies documented the effects of general habitat alteration and human presence on wolverine. These studies helped to provide insight into the potential impacts a golf course might have upon wolverine.

Wolverine Sensitivity to Habitat Alteration

Wolverine may be attracted to the increased prey base often associated with golf courses. A golf course will convert forest to open space and change predator-prey composition and dynamics. Wolverine occupy a variety of habitats that vary seasonally and geographically. Krebs and Lewis (1999) have been studying wolverine in Revelstoke, B.C. for four years, and found that habitat patch size, location and prey density/ distribution are important factors in determining wolverine habitat use. Banci (1994) reports that general characteristics associated with wolverine distribution include areas with an adequate supply of prey species as well as remoteness from human disturbance and presence. Wolverine may be susceptible to habitat alteration if it results in fragmentation and isolation between habitat patches. Most likely wolverine will be sensitive to habitat alteration if it is supplanted with human development and increases the number of humans in an area (Banci, 1994).

Wolverine Sensitivity to Human Presence
A golf course development may likely displace wolverine because of the increase in human presence. The current distribution of wolverine coincides with areas of remoteness (Banci 1994). In fact the notion that wolverine occupy high elevation habitat may be due to their avoidance of human disturbance that often occurs in the lower montane areas (Banci, 1994). Krebs and Lewis (1999) found that females tend to remain in remote wilderness area at higher elevations, while the males have much larger home ranges and are found in lower elevations for scavenging purposes and travel, particularly in the winter. Wolverine are susceptible to activities that supplant habitat with human developments such as oil and gas sites, recreational developments and human settlements (Banci, 1994). These developments are often associated with an increase in human access to remote areas and tend to push out the wolverine. However, wolverine have been observed frequenting garbage dumpsites near human settlements in northern British Columbia (Banci, 1994).

Golf Courses as Movement Corridors for Wolverine
A wolverine may use a golf course as a travel corridor but they will be sensitive to the availability of cover. A golf course must maintain sufficient cover if it is to function as a wolverine travel corridor (Witmer et al., 1998). Hornocker and Hash (1981) studied the effects of large openings within forest habitat on wolverines and found they prefer to travel around the edge. When they did cross a large opening, it was with a running gait and in a straight line. However, the study also indicated that there was no difference noted in overall movement, habitat use or behavior between logged and un-logged areas. Krebs (pers. comm.) also pointed out that they are active in the tundra area and, therefore, cross vast open areas at higher elevations where there is limited human presence.

Even if sufficient cover is available, wolverine remain sensitive to human presence. A golf course may act as an important travel route for dispersing females and males. Although, wolverine tend to be found in higher elevation areas, the lower valley bottoms are essential travel corridors, especially for recolonizing young females and for males dispersing between habitat patches. A travel corridor that connects habitat patches does not have to be high quality self-sustaining habitat. Low quality habitat may be sufficient provided there are no barriers to movement, such as a high level of human presence (Banci, 1994). Wolverines appear to be sensitive to any increase in human presence (Banci, 1984). They have been observed crossing areas inhabited by humans by shifting their activity patterns to night (Hash, 1987).

4.3.3.3 Conclusion
It appears that a golf course may deter wolverine use and movement during periods of high human activity. The impacts are difficult to discern given the paucity of wolverine habitat and movement information. Banci (1994) suggested that the impacts of land-use activities upon wolverine is similar to the impacts upon the grizzly bear. Both species are extremely sensitive to human activities and tend to avoid human contact.

A golf course affects wolverine by increasing the prey base, removing cover, and increasing humans. Wolverine may be attracted to the increased prey base but it is more likely that a golf course, usually in a lower elevation setting, will be used as a travel corridor, specifically for males traveling between habitat patches and for recolonising females. The use of a golf course by a wolverine is likely periodic and unpredictable. For a golf course to function as a travel route it must have sufficient cover and low levels of human presence. Considering the wolverine's tendency to avoid humans, a golf course may impede movement and act as a barrier to dispersal, especially during peak periods of use. Alternatively, there is the possibility that a wolverine may travel through the area at night to avoid periods of human activity. Regardless, a golf course with too many humans and not enough cover will reduce habitat effectiveness by restricting or altering wolverine use of the area.

The effects of a golf course upon a wolverine population are difficult to determine. If the golf course acts as a barrier to a critical movement corridor then the long-term population viability may be threatened due to isolation between habitat patches. Wolverine, particularly males, have very large home ranges and require suitable travel routes between habitat patches. The travel routes need not be high quality habitat but must not deter movement. The effect of a golf course on the wolverine population will, therefore, depend upon the importance of the area as a travel corridor.

4.3.4 American Marten (*Martes americana*) and Fisher (*Martes pennanti*)
4.3.4.1 Research and Observations

Research
There was only one study found that addressed the impact of a golf course upon marten and fisher habitat and movement. There were no studies found that assessed the impact of activities during the golfing season. In addition there were no studies found that assessed the use of a golf course prior to and post golf course development.

In Banff National Park, the large mammal winter monitoring program (see elk above) has never recorded marten or fisher tracks on or near the golf course (Duke, 1999).

Observations
There were very few anecdotal observations found which could provide insight into the relationships between marten, fisher and golf courses.

In Alberta, Pattison (pers. comm.) observed pine marten on the edge of the Banff Springs Golf Course in the summer.

In Colorado, Waite (pers. comm.) observed pine marten living in native forest habitat on the edge of a golf course. The other side of the golf course had moderate levels of human development.

4.3.4.2 Golf Courses as Habitat and Movement Corridors for Marten and Fisher
Given that there were no studies and limited observations assessing the relationship between fisher, marten and golf courses, it is difficult to come to conclusions regarding changes to their use and movements. There were, however, a few studies that evaluate the impacts of habitat alteration and the effects of increased human presence on these species. These studies can assist

in identifying the potential impacts of a golf course on fisher and marten habitat use and movement.

Marten and Fisher Sensitivity to Habitat Alteration
The alteration of forest cover by a golf course is likely detrimental to forest specialists such as the fisher and marten. The same changes which improve habitat for generalists and grassland-dependent species (i.e. ungulates), reduce habitat potential for forest-dwellers. Where these species are concerned, a golf course will negatively change the landscape ecology of an area by opening up the forest, fragmenting the habitat, changing vegetation composition and communities and altering patch and corridor sizes and locations.

The fisher has been associated with a variety of successional stages particularly within forest riparian areas (Heinemeyer & Jones, 1994) These areas are used for resting, feeding and as travel corridors. Regardless of the successional stage of the forest used by the fisher they need to have a high canopy closure (Powell & Zielinski, 1994).

The marten is associated with late successional coniferous stands, particularly those with complex structures near the ground (Buskirk & Ruggiero, 1994). Marten are dependent upon the structural diversity of woody debris at ground level (Witmer et al., 1998).

Both species avoid open areas so habitat effectiveness will be reduced if forest cover is removed. Fishers have been recorded avoiding open areas over 25 meters across (Powell & Zielinski, 1994). In other studies, marten were observed crossing open areas between 10 to 100 meters (Spencer et al., 1983). A study in northern Alberta that assessed the effects of a pipeline on marten movement indicated that although areas adjacent to the pipeline were used, marten generally avoided the pipeline openings (Eccles and Duncan, 1986). A similar study on fisher indicated that they rarely used large openings, clearcuts or grasslands (Powell and Zielinski, 1994).

Golf course developments, therefore, introduce habitat alterations that result in both direct and indirect negative consequences. Directly, a loss of forest habitat through development of a golf course may alter marten/fisher distribution, and limit the potential for population expansion and colonization of other ranges (Powell and Zielinski 1994). In addition they may lose resting sites, denning areas and foraging habitat (Powel1 and Zielinski,1994). They may continue to use forest habitat adjacent to a golf course. Indirectly, however, the alteration of habitat by a golf course attracts generalist species, such as the coyote and fox, which tend to out compete forest specialists. Such generalist species do more than compete for prey; they will kill fisher and marten (Buskirk and Ruggiero, 1994).

Marten and Fisher Sensitivity to Human Presence
It is difficult to evaluate the effect of human presence on the fisher and marten but studies suggest that they may avoid areas of high human presence such as a golf course during the golfing season. Powell and Zielinski (1994) noted that fisher generally avoid areas where there is human presence. In Connecticut a population of reintroduced fishers avoided residential areas (Faccio, 1992). Martens tend to be shy and are often referred to as wilderness animals (Powell and Zielinski, 1994).

Golf Courses as Wildlife Corridors for Marten and Fisher
For a golf course to function as a fisher and marten travel corridor, forested corridors should be maintained with the appropriate structural diversity (Witmer et al., 1998). Maintaining forest on a golf course, especially through riparian areas, might help to ensure that the fisher and marten are still able to move through the area.

4.3.4.3 Conclusion
A golf course affects the fisher and marten by altering habitat, increasing human presence, and encouraging generalist species. The fisher and marten are specialist species, dependent upon specific stages and structure of forest patches (Heinemyer and Jones, 1994 & Powell and Zielinski, 1994). They are susceptible to habitat alteration that reduces forest cover and increases the area of grassland and edge (Conrad, pers. comm.). In addition, an increase in edge generally attracts generalist species, such as coyote and fox, which out compete and can kill a fisher/marten (Buskirk and Ruggiero, 1994). For the fisher/marten to use the golf course as a travel corridor, they generally require connecting areas of forest cover moderately free of human disturbance. The impacts of human disturbance on marten and fisher are not well documented, although there is some evidence that they may be displaced from areas with a high level of human presence (Faccio, 1992 & Powell and Zielinski, 1994).

4.3.5 Cougar (*Felis concolor*)
4.3.5.1 Research and Observations

Research
Two quantitative studies were found that assessed the impact of golf courses on cougar habitat and movement.

The large mammal winter monitoring program in Banff National Park (see elk above) recorded cougar occasionally on the golf course. During the first six years of winter surveys, a 1996 recording was the only instance of a cougar crossing the golf course (Stevens et al., 1996). However, during the 1999/2000 winter season cougar were recorded for the first time using the course as an east-west travel corridor. They crossed the golf course on seven occasions. Six of these crossings occurred within covered areas; the other one occurred when a cougar pair crossed openings at the narrowest point of the corridor. It is not known if the cougar crossed during the day or night. In addition, eleven cougar kill sites were recorded on the golf course, four of which were in the open (Duke, 2000). The increased use of the golf course by cougars may be attributed to a road closure for the 1999/2000 winter season. This road buffered the golf course and was commonly driven by tourists.

A study in Waterton Lakes National Park on radio-collared cougar observed two individuals living on the golf course during the summer. The cougar were observed hiding in dense stands of aspen during the day. Watt (pers. comm.) attributed the cougars’ use of the course to ungulate presence and a high availability of dense cover for hiding and stalking.

Observations
Numerous anecdotal observations were found that provided insights into the relationship of cougar and golf courses.

Hornung, (pers. comm.) in Alberta has observed cougar on the Kananaskis golf course.

Andre (pers. comm.), a wildlife biologist in Colorado, observed cougar hunting on golf courses that had sufficient cover for hiding and stalking prey. Cougar didn't appear to be sensitive to human presence, although there was no data on the distribution of cougar prior to golf course development.

Spowart (pers. comm.), a wildlife biologist in Colorado, noted that cougars were attracted to an increased prey base (primarily ungulates) on golf courses. Cougar that became habituated were often involved in human-cougar conflicts and had to be translocated. Davies (pers. comm.) also recorded habituated cougar on a Colorado golf course, however he has avoided translocating cougar by implementing a local education program.

In Montana, Coates (pers. comm.) has also observed an increase in the prey on a golf course. This increase has attracted cougar. Montana's wildlife policy is to view each problem animal independently. If a cougar acts aggressively in an encounter with a human it is removed from the population.

4.3.5.2 Golf Courses as Habitat and Movement Corridors for Cougars
There were numerous studies found on the effects of both habitat alteration and increased human presence on a cougar population. These studies, combined with golf course observations and research, provide insight into the compatibility of cougar and golf courses in the Rocky Mountains.

Cougar Sensitivity to Habitat Alteration
A cougar will use a golf course if there is a significant amount of cover for hiding and stalking prey.

Cougar are adapted to a wide variety of habitats and elevations, but they prefer mixed forest, shrubby cover types and areas where there is an adequate supply of prey species (Witmer et al., 1998). A golf course may replace forest with grassland and may, therefore, attract ungulates. This change in vegetation composition and increase in prey may, in-turn, attract cougar, To stalk this prey, cougar are dependant upon a certain amount of vertical and horizontal cover (Murphy, 1998). Therefore, a golf course has the ability to attract cougar to the area but must maintain forest patches for protection and for hunting prey (Murphy, 1998, Witmer et al., 1998).

Cougar Sensitivity to Human Presence
A golf course will increase human presence in an area, which will have varying degrees of impact on a cougar depending upon the cougar's tolerance and, possibly, its gender. Jalkotzy (pers. comm.) noted that cougar may eventually adapt to living adjacent to humans. Jalkotzy and Ross (1995) studied the effects of human activities on the Sheep River cougar population in Alberta. Although cougars were not displaced by human activity, a few females reverted to the

backcountry for birth or when their offspring were very young. They also noted that cougar, in general, occupied an area 250m from heavily used campgrounds and picnic sites.

A high level of human activity may displace cougar from an area. A study by Beier (1995) concluded that even if humans do not alter the habitat, continuous, concentrated human presence would eliminate use of an area by non habituated cougar**.** The Banff National Park winter monitoring program may support these findings. Prior to closure of an adjacent road, cougar use of the course was minimal. After a closure was implemented prior to the 1999/2000 winter season, cougar began hunting in and generally passing through the area. The restriction of human use may have favoured a cougar return to the area. However the number of humans using the golf course in the winter prior to the road closure was not determined, therefore there is some question as to the role the road closure played in the increase in cougar activity.

Cougar may change their activity patterns to access resources when humans are inactive (Van Dyke et al., 1986). If cougar must change their temporal patterns, habitat effectiveness may be reduced (Jalkotzy, pers. comm.).

Some cougar may become habituated to a golf course, providing them access to an increased prey base but also increasing the likelihood of human-cougar interaction. Andre (pers. comm.) noted that cougar are attracted to golf courses with an abundance of prey species. This may increase the likelihood of human-cougar conflicts particularly in areas where a golf course is adjacent to a human settlement. However, there are no studies that document this (Coates, pers. comm.). Theoretically, a cougar may be interested in attractants, such as dog food and domestic pets, generally found around areas with humans (Witmer et al., 1998). Management action in these situations often results in translocation of the cougar or its removal from the population. On average, habituated cougar probably do not live as long as their wild counterparts (Jalkotzy, pers. comm.).

Golf Courses as Movement Corridors for Cougars
For a golf course to function as a travel route, one must consider the amount of cover available and the level of human presence. Beier (1995) found that cougar used corridors less if they were exposed to noise, lighting and domestic dogs. Cougar used trails commonly used by hikers and bicyclists but only before sunrise. A golf course will most likely act as a spatial and/or temporal barrier to certain individuals during periods of high human use.

4.3.5.3 Conclusion
The effect of a golf course on cougar depends upon the level of human presence, the amount of hiding cover on the course and the level of human tolerance for cougar. Cougar may be attracted to an improved prey base on a golf course, however they may be displaced through their intolerance to humans or through management action, particularly if the golf course is associated with other developments.

A golf course may affect cougar by altering habitat, increasing human presence and shifting their activity patterns. A golf course that has attracted a prey base may attract cougar (Spowart, pers. comm.). The ability of a cougar to hunt the prey on a golf course is dependent upon a sufficient amount of vertical cover existing for hiding and stalking. Cougar response is plastic - they will react differently to an increase in human presence. Some individuals will be displaced, while others might shift activity patterns and /or become habituated (Andre, pers. comm.). Cougar that are displaced or that shift activity patterns experience reduced habitat effectiveness because they are permanently or temporally restricted. Although habituation allows cougar access to habitats and prey species which intolerant individuals are restricted from, it often results in human-cougar conflicts and management action. Management action may include translocation or removal from the population (Coates, per. comm.). Davies (pers. comm.) noted that wildlife conflicts may be partly alleviated with education programs. The use of a golf course as a travel corridor is also dependant upon the level of human presence. Cougar are sensitive to lighting, dogs and noise; a corridor that includes these may act as a barrier to movement (Beier, 1995). Tolerant cougar may continue to use a golf course as a corridor although they may only do so nocturnally.

A golf course's impacts should be assessed in accumulation with those from other regional developments (Watt, pers. comm). It is difficult to qualify the impacts of a single development, such as a golf course, on a cougar population. The ability of a cougar to live, hunt prey, or travel through a golf course is associated with the level of human tolerance of cougars. Management issues are more likely to arise when the golf course is associated with human settlements, which offer attractants to the cougars and more opportunities for conflict. In a wilderness matrix a cougar has more habitat and movement options and is less likely to experience human-cougar conflicts.

4.3.6 Lynx (*Lynx canadensis*)
4.3.6.1 Research and Observations

Research
There was very little information found that specifically addressed the impact of a golf course on lynx movement and habitat use.

The large mammal monitoring program in Banff National Park (see elk above) has recorded only four lynx events on the golf course, which occurred in the 1993/94 and 1995/96 winter seasons (Stevens and Owchar, 1997). The lynx movements occurred on the portion of the golf course furthest away from human development (Heuer, 1995). The presence of lynx was documented from tracking data and the time of day could not be determined.

Observations
There were no anecdotal observations reported of lynx using golf courses.

4.3.6.2 Golf Courses as Habitat and Movement Corridors for Lynx
There were a few studies found which documented the effects of habitat alteration and human presence on lynx. Although we have a lack of direct evidence, these studies may show some potential impacts of golf course development in the Rocky Mountains on lynx habitat use and movement.

Lynx Sensitivity to Habitat Alteration
Lynx habitat effectiveness may be reduced by a golf course development, as it converts forest to open space. Like marten and fisher, they are forest specialists; therefore converting forest to an open environment is in direct conflict with their needs (Conard, pers. comm.). They are

associated with mid to upper elevation coniferous forests and require a variety of seral stages that are linked together to provide protective cover (Witmer et al, 1998 & Claar et al, 1999). A golf course may clear forest in favour of open areas that are not generally used by lynx as habitat. Although they may travel through openings, they have not been observed hunting in them (Koehler and Aubry, 1994).

Habitat alterations that favour generalist species often do so at the expense of specialists. Forest fragmentation and increases in edge habitat from golf course development may encourage generalists such as coyotes and great-horned owls that are in direct competition with lynx for food and space (Buskirk et al, 1999).

A golf course may preempt the ecosystem processes that produce the diverse forest stands required by lynx. Lynx are somewhat dependent upon fire to maintain diverse seral stands in a natural environment (Apps, pers. comm.). Human developments, such as a golf course, often restrict the use of controlled burns as a management tool. In addition, human developments are often buffered by thinning of dense forest stands to minimize the fire potential. Such a loss of forest process and structure may be detrimental to lynx.

Lynx Sensitivity to Human Presence

Lynx response to increased human presence varies but they may generally tolerate a moderate increase before changing their activity patterns or leaving an area entirely. Information documenting lynx sensitivity to human presence is limited (Clarr at al, 1999). However, anecdotal evidence suggests that lynx are able to withstand a moderate level of human disturbance with the exception of activity around den sites, which has caused abandonment in the past (Mowart et al, 1999, Witmer et al., 1988 & USDI Bureau of Land Management et al, 1999). If human activity becomes too high, lynx may avoid the area. For example, the Banff National Park large mammal winter monitoring program has only observed lynx on the portion of the golf course furthest away from human activities (Stevens and Owchar, 1997). Alternatively, in areas of high human use, lynx may remain but restrict their movements to dawn and dusk, provided there is secure cover to hide in during the day (Koehler and Aubry, 1994).

Golf Courses as Movement Corridors for Lynx

The use of a golf course as a travel corridor by lynx will depend upon the availability of cover, the number of generalist species and the level of human presence. In highly mountainous terrain lynx movements will usually occur along major valley bottoms (Apps, 1999). Maintaining these travel routes may be essential for the long-term viability of a lynx population by preventing population fragmentation. Lynx move long distances but generally through forest cover. Open areas, both natural and human induced, will discourage travel thereby disrupting movement patterns (Koehler and Aubry, 1994). Koehler and Aubry (1994) noted that a suitable travel corridor would consist of forests with a closed canopy greater than 2 meters in height. Lynx may travel through openings less than 15 m wide, provided there is adequate cover on both sides (Koehler and Aubry, 1994). Lynx have also been observed at night crossing open spaces that are less than 200 m wide, provided there is cover on both sides of the opening (USDI Bureau of Land Management et al, 1999). However if open areas have attracted generalist species, lynx may avoid traveling through them. Finally, lynx may avoid traveling through areas of high human activity. A survey in Lake Louise found that lynx shifted movement activity to dawn and dusk to cross areas used frequently by skiers during the day (Stevens et al., 1996). In short, lynx may use a golf course as a travel corridor if it maintains contiguous forest with narrow open crossings, maintains periods of low human use and doesn't attract a high number of generalist species.

4.3.6.3 Conclusion

The effect of a golf course on a lynx primarily depends upon the level of habitat alteration and secondarily upon the level of human presence and generalist species attracted to the course. The conversion of forest to open space is a direct loss of habitat to a lynx (Apps, Conard, pers. comm.). The open space may favour generalist species, such as coyotes, which out compete, displace and may even kill a lynx (Buskirk at al, 1999). Lynx may be moderately tolerant of humans, but high levels of human presence can displace individuals from the area. A golf course might still be used as a travel route to access more secure habitat patches provided that narrow fairways and efficient cover on both sides are maintained. High levels of human activity may cause lynx to shift their temporal travel patterns to dawn and dusk, as observed on Lake Louise Ski Hill (Stevens et al, 1996). If human presence is too high the golf course may act as a barrier to movement for certain individuals.

It is difficult to determine the effects of a single development, such as a golf course, upon an entire lynx population due to their large home ranges and elusive nature. Apps (pers. comm.) cautions that a lack of observation may not indicate absence of the species from an area. A golf course that converts forest to open space will result in habitat loss for a lynx population. This may be particularly detrimental to the population if it represents a loss of some of the only suitable habitat in a heavily developed landscape. The ability of the golf course to act as travel corridor may be essential in ensuring access to remaining habitat patches. If the golf course becomes a physical barrier to lynx movement because of either a lack of cover or high levels of human use, it may help fragment a population. A golf course therefore needs to be assessed in consideration of other developments while bearing in mind its relative importance as a habitat patch or in connecting habitat patches.

4.3.7 Wolves *(Canis lupus)*

4.3.7.1 Research and Observations

Research

There was only one quantitative study found that addressed the impact of a golf course on wolf movement and habitat use.

The large mammal winter monitoring program in Banff National Park (see elk above) has occasionally observed wolves on the golf course (Duke, 1999). Heuer (1995) noted that prior to the large mammal survey there were no observations of wolves using the golf course. In the 1994/95 and 1996/97 winter season wolves were recorded near or crossing the golf course. No wolf observations occurred on the golf course during the 1995/96 and 1997/98 winter season. This was attributed partly to the lack of snow and poor tracking conditions (Duke, 1999).

There was a notable increase in wolf use of the golf course in the 1999/2000 winter season. Wolves used the course as a travel route and hunted on the open fairways. This is the first study season that wolves were seen traversing and hunting on these fairways. The increase in use may be partly attributed to the closure of a road in the 1999/2000 winter season which buffers the golf course and was commonly driven by tourists. . However the number of humans using the golf course in the winter. prior to the road closure, is unknown. Furthermore, the investigators are unsure whether the usage represents a temporal adaptation, i.e. from day to night. All the sequences involved two wolves, which are believed to be from the newly formed Fairholme Pack (Duke, pers. comm.).

Observations
In addition to this study, there were some anecdotal observations reported that provide understanding into the relationship between wolves and golf courses.

Wolves continue to use golf courses in Kananaskis Country, Prince Albert National Park and Riding Mountain National Park. On the Kananaskis and Silvertip golf courses wolves have killed elk in the winter when there have been very few people around (Callaghan, pers. comm.). The former (with the exception of Silvertip) are all ‘wilderness’ golf courses with minimal development. At golf courses with surrounding development, less use or complete avoidance has been documented. In general, wolves generally avoid Banff’s golf course even though it is in the middle of an identified wildlife corridor (Paquet, pers. comm.). Wolves continue to use the Silvertip golf course, although on the whole the use of the course by large carnivores appears to have declined (Paquet, pers. comm.).

4.3.7.2 Golf Courses as Habitat and Movement Corridors for Wolves
Studies were found that document the effects of general habitat alteration and human presence on wolves. These studies, in conjunction with observations of wolves on golf courses, provided insights into the potential of wolves using golf courses as habitat or as movement corridors.

Wolves Sensitivity to Habitat Alteration
Wolves may use altered habitat provided by a golf course, especially if it attracts a congregation of prey species. Wolves are widely distributed on the landscape, implying an inherent ecological flexibility and a lack of habitat specificity. Wolves tend to be habitat generalists in terms of vegetation and terrain used (Mladenoff et al 1995). They are not highly sensitive to cover and will not be deterred from open spaces (Callaghan, pers. comm.). Habitat use of Rocky Mountain wolves have been correlated directly with ungulate distribution and abundance (Claar et al, 1999). Wolves may, therefore, be attracted to prey species which, in turn, are drawn to a golf course (see ungulates, above). Although wolves may not be impacted by the habitat alteration of a golf course development, they are generally shy of humans (Callaghan, pers. comm.).

Wolves Sensitivity to Human Presence
A golf course will increase the level of human presence in the area, which will have various degrees of impact on wolves depending upon the individual wolf’s tolerance and human acceptance of wolf-human conflicts (Callaghan, pers. comm.). Wolves exhibit behavior plasticity, therefore the response of a wolf to an increase in human presence and development is individualistic (Clarr et al, 1998). The impact depends upon the intensity, duration and predictability of the disturbance as well as the individual wolf. Some individuals may tolerate a lot of disturbance while other may be extremely sensitive (Chapman, 1977). This may disrupt social structure of a wolf pack and act as a filter to movement. (Paquet et al., 1996). Some

wolves may eventually become habituated and accept human presence. Although this allows the wolf access to resources on a golf course, it may be more detrimental than fleeing the disturbance since habituated wolves are generally easier targets for persecution by humans (Claar et al, 1999).

There is not a clear threshold on how many humans the majority of wolves will tolerate before they are displaced from an area. A study in Jasper indicated there was no carnivore activity where human activity exceeded 1000 people per month (Mercer et al., 2000). On the Banff Springs Golf Course, wolf movement occurred and a kill site was observed on the golf course when 1305 people events were recorded in a month, however, such activity is rare (Duke, 2000). The temporal period of the wolf kill and movements were unknown and it is likely that the wolf kills and travel occurred during periods of human inactivity, such as at night. The Jasper study of the Three Valley Confluence found a direct correlation between an increase in human presence and a decrease in carnivore use (Mercer et al., 2000). In addition wolves appear to be absent from the area during the summer period but returned in the winter to areas of low human use. A wolf trapping program was initiated in the summer of 1999 and no wolves were caught (Mercer et al., 2000). These studies and anecdotal observations of wolves on golf courses support the notion that the use of the golf course by a wolf may be correlated with the number of humans in the area. Golf courses where wolves have been observed have generally been wilderness courses associated with little development (Paquet, pers. comm.).

Golf Courses as Movement Corridors for Wolves
A wolf's use of a golf course as a travel corridor will likely depend upon the level of human presence. Studies indicate that wolves will use linear disturbance areas as travel routes, specifically if the disturbed areas occur where human use is low (Thurber et al., 1994). Although wolves are generally shy, they exhibit behavioral variation and their tolerance to humans will be individualistic. Wolves have been observed traveling through golf courses in a wilderness context (Paquet, pers. comm.). However they are almost absent from highly developed areas, such as the Banff Springs Golf Course, (with the exception of two individuals this year) or the Three Valley Confluence area in Jasper (Paquet, pers. comm., Mercer et al., 2000).

4.3.7.3 Conclusions

The effects of a golf course on a wolf will primarily depend upon the congregation of prey species, the amount of human presence in the area and the context of the golf course. A golf course may improve access to congregating prey until human activity deters wolves. Deterrence is amplified if a course is established within a developed area.

A golf course will impact a wolf by increasing human presence, by altering prey distribution and possibly by shifting travel routes. If the golf course attracts prey species it may indirectly attract wolves to the area. The ability of a wolf to hunt the prey attracted to a golf course is variable as they exhibit individualistic behavior. Therefore, a golf course may act as a filter by allowing certain individuals access while restricting others. This may disrupt pack structure (Clarr et al., 1999). Habituated individuals gain access to the prey species and habitat but are also more likely to experience human-wolf conflicts and persecution by humans. A wolf may move through a golf course as a travel route but given the general sensitivity to human presence, it will most likely occur during low periods of human activity, such as at night. Wolves have been observed moving through golf courses in wilderness settings but only two individuals have been observed during a winter season using the Banff Springs Golf Course (which is associated with other developments) as a travel corridor. A golf course associated with other developments will likely have less travel route options and is more likely to deter wolf movements than a golf course in a wilderness setting.

4.3.8 Coyote (*Canis latrans*)
4.3.8.1 Research and Observations

Research
There was only one quantitative study found which addressed the effects of golf courses on coyotes.

The large mammal winter monitoring program in Banff National Park (see elk above) frequently, observed coyote on the golf course during all years (Stevens and Owchar,1997, Duke, 1999, Stevens et al., 1996 and Heuer et al., 1998).

Observations
There were two anecdotal observations reported regarding coyotes on golf courses.

Pattison (pers. comm.) has observed coyotes on the Banff Springs Golf Course. Andre (pers. comm.) observed an increase in coyotes around a golf course and housing development in Colorado.

4.3.8.2 Golf Courses as Habitat and Movement Corridors for Coyote
Studies were found that documented the effects of general habitat alteration and human presence on coyote. These studies, combined with observations and research on coyote, provided some understanding of their compatibility with golf courses.

Coyote Sensitivity to Habitat Alteration
The increase in edge habitat associated with golf courses will attract coyotes. A golf course will alter habitat, generally by replacing forest with grasslands and, therefore, by increasing heterogeneity and edge. The coyote's geographic range has increased in correlation with an increase in agriculture, clearcuts and other human developments (Voight &Berg, 1987). They are generalists, occupying a diversity of habitats and can even adapt to survive in urban areas (Bekoff 1982). Coyote do require some cover for hiding and resting but are not as sensitive as other species (Witmer et al., 1998). In general, changes that discourage animals with narrower niches, i.e. forest specialists, tend to favour the adaptive coyote.

Coyote Sensitivity to Human Presence
Coyotes should adjust to the increase in human presence associated with a golf course. A golf course will increase the number of humans on the landscape during the golfing season and increase access during other seasons. Coyotes are habitat and diet generalists and respond positively to human presence as other species, such as forest specialists, are typically displaced (Witmer et al., 1998). During periods of high human activity coyotes were the only carnivore, with the exception of black bears, that were not displaced from the Three Valley Confluence area in Jasper (Mercer et al., 2000). Vogel (1983) evaluated the impact of residential settlements on

wildlife species and found the number of coyotes remained the same as before the development. Coyotes are easily habituated to golf courses as exemplified by observations of coyotes on golf courses associated with heavy development and use (Andre, Pattison, pers. comm.). Unfortunately habituation often results in human-coyote conflicts, such as predation on domestic pets and livestock, consumption of crops and gardens and, occasionally, attacks on humans (Witmer et al., 1998). However, Clarr et al (1999) noted "Given the ability of coyotes to sustain themselves, even under most removal efforts, it appears that secondary consequences of human recreational activities upon coyotes have been and will continue to be nominal."

Golf Courses as Wildlife Corridors for Coyote

Coyotes may use a golf course as a travel route, specifically if wolves are displaced from the area. Human presence has little impact on coyotes and they are the species least likely to be displaced. Coyotes may even displace forest specialist species by disrupting the movement of these species through forest areas on a golf course.

4.3.8.3 Conclusion

A golf course should benefit coyotes by displacing other carnivores and increasing the available edge.

A golf course affects coyote by altering habitat, increasing human presence and displacing competing species. A coyote will thrive on the altered habitat provided by a golf course, as there will generally be an increase in edge (Voight &Berg, 1987). They do require some cover for protection, denning and resting (Witmer et al., 1998). Coyote easily adjust to human presence and often thrive in areas where other carnivores are displaced. Habituation is likely to increase the possibility of human-coyote conflicts, which may lead to indirect or direct mortality. Given that coyotes adjust to human activities and developments, a golf course will likely have a nominal or favourable effect on a coyote population (Clarr et al, 1999)

5.0 KNOWLEDGE GAPS

This literature review has identified several areas where information is deficient:

- No quantitative studies exist documenting the effects of golf courses on large mammal movements.

- No long-term monitoring program exists that assesses wildlife habitat use and movements prior to and post golf course development in the Rocky Mountains. In particular, there are no monitoring programs which monitor changes in summer use by various species with the exception of the Silvertip Golf Course in Canmore, Alberta.

- Little information exists on the long-term effects of aversive conditioning. Can wildlife be deterred at certain periods but return during times of low use?

- No surveys exist assessing the possibility of golf courses acting as mortality sinks, especially for carnivores attracted to an increased prey base. Such a survey could compare the level of habituation and conflict which arises on a (control) wilderness course versus courses associated with varying levels of development.

Appendix D lists current/future research projects that assess the impacts of golf courses upon wildlife.

6.0 ENHANCING WILDLIFE HABITAT

This section outlines mitigation actions to enhance wildlife habitat on golf courses. We found very few suggestions that do not result in displacement of wildlife from the golf course. If the wildlife is dependent on the golf course for habitat or movement these methods may not be appropriate.

There are three phases to consider in golf course development: design, construction and long-term operation/maintenance. Wildlife compatibility on a golf course is best addressed before development as maintaining natural areas is less expensive than enhancing degraded habitat at a later date. The design phase is critical as it has the potential to reduce the impact upon critical wildlife habitat. The development phase can be adjusted to minimize impacts on breeding sites and avoid temporal periods whereby wildlife are dependent upon the golf course. The long-term maintenance of the golf course should incorporate adaptive measures that enhance human co-existence with wildlife.

Design Phase
Golf course designers have approached the issue of wildlife and golf courses in two ways. Courses are either designed to accommodate or to deter wildlife. Planners and wildlife biologists can consider critical habitat needs when design is underway. In a Rocky Mountain environment where valley bottoms are used extensively by both humans and wildlife, the need for such consideration is amplified. Habitat and movement information should be considered up front – a golf course should be designed around important wildlife habitat rather than the other way around.

The most common approach to evaluating the effects of a golf course is the environmental impact assessment or EIA. Ideally, an EIA is carried out at the land-use planning stage before a golf course is even considered for an area. If a golf course is inappropriate, the proponent should be spared the expense by being told so from the start. If not (or if a golf course may be appropriate), then the EIA should be anticipated in the course design. A proper EIA will ensure the design of the course minimizes adverse effects of development. Designers should give prudent and ardent attention to critical wildlife habitat (corridors and patches) associated with the proposed development site. A proposed golf course could disrupt or destroy critical habitat, in particular that of endangered, threatened or rare species (British Columbia Environment Lands and Parks, 1994). However golf courses can minimize their impacts if they have a detailed site assessment, comprehensive scoping measures, long-term planning, careful construction practices and proper management programs.

As one example, natural areas, made up of specific types of vegetation to the region, can be designed as features to provide a natural setting, as well as benefit the conservation and protection of existing wildlife habitat (Love, 1999). These natural areas should encompass both wildlife corridors and a diversity of patches of various sizes and structures. The corridor width, shape and size will depend upon the species identified as using the area for movement. Exact figures are difficult to discern as they vary depending on the golf course context, the needs of the species concerned and the tolerance of these populations to humans. Areas that are sensitive to species such as riparian zones for wildlife travel or mineral licks and winter foraging areas for ungulates should be preserved. Many species will benefit from buffers of forest or dense vegetation between the fairways and holes, as it provides cover, security and travel routes.

Innovative measures attending the golf course are also encouraged. If a golf course is to be developed, it increases the importance of maintaining habitats in surrounding lands. Developers in Montana have donated conservation easements on land adjacent to the golf course for the benefit of wildlife (Andre, pers. comm.). The less human development and more cover around the golf course the more likely the golf course will continue to accommodate wildlife. For example, species such as cougar and bears have been observed hiding in patches alongside or within the golf courses during the day and hunting and/or foraging at night.

Construction Phase

Once the proponent and local officials have agreed that a golf course may proceed and that a particular design is appropriate, the timing and methods of the construction must ensure minimal adverse effects upon various species. For instance, development may avoid important calving and lambing areas during the winter/spring. The EIA should identify the temporal and spatial needs of relevant species and designate periods/places which construction should avoid.

Long –Term Operation/Maintenance

If a golf course is to minimize its operational effects upon wildlife, it should incorporate adaptive measures within its operational plans. Often certain species and/or situations are overlooked during the EIA/design phase. If a course exists within important wildlife habitat, the operators should be prepared to incorporate adjustments as unforeseen events arise. If wildlife is to be maintained, tolerance is essential.

A number of groups have recently developed environmental guidelines for golf courses (Dodson, pers. comm.). The most popular and well-known program is Audubon International's Sanctuary Certificate Program. This is a voluntary initiative where golf course managers follow a six point program to minimize environmental degradation. One component of the program is enhancing wildlife habitat on the golf course. Although this program has merit and deserves credence, it is aimed specifically at many of the smaller vertebrates and bird species and focuses on golf courses in the Southern United States. The AI program would have to be adapted to pertain to Rocky Mountain golf courses where large mammals and forest carnivores are dependent upon valley bottoms for movement, foraging and resting sites.

The golf course should be encouraged to develop a wildlife management plan that highlights the tolerance level of the golf course to different species of wildlife, especially if endangered or threatened species use the area. Mitigation activities could include course closures, later starts and earlier finishes to the golf day, purchase of a conservation easement on neighboring lands, access management of the golf course in the off season and education campaigns. The wildlife management plan should include a monitoring program that assesses the ongoing relationship between the golf course and wildlife. It should also detail the response of course managers to habituated species. Habituation of species should generally be avoided as it results in human-wildlife conflicts whereby the animal is usually translocated or removed from the population. There are a number of ways to reduce human-wildlife conflict, such as reducing suitable habitat that attracts wildlife or through aversive conditioning (NRCB, 1992). Neither of these is appropriate if the golf course is to mimic wildlife habitat or serve as a wildlife corridor.

7.0 CONCLUSION

The impact of a golf course on wildlife will vary depending upon the wildlife species, the golf course context, the amount of habitat alteration, and the level of human presence. In general, there appears to be very few long-term benefits to wildlife from a golf course development. This is due primarily to the increase in human use associated with the golf course and the intolerance of humans to habituated wildlife. Habituated wildlife increase maintenance costs and raise safety concerns. There appears to be a gradient of impact based upon the level of habitat alteration, human increase and the golf course context. Some species may be attracted to, while others are displaced from, the altered habitat on a golf course however, as humans increase habitat effectiveness is reduced for most species. As human presence and associated developments increase so does the likelihood of wildlife displacement, either through the animal's own intolerance or through management action. In general, therefore, a golf course may impact wildlife in a number of ways - by altering habitat, by increasing human presence, by displacing individuals, by shifting movement corridors and/or by contributing to indirect or direct mortality.

A golf course will alter the landscape ecology of an area by converting forest to open space, by enhancing the quality of grassland forage, by changing community composition and dynamics and by physically altering corridor and patch locations and sizes. Many species will be attracted to the enhanced grassland forage offered by a golf course. For example there are anecdotal observations of ungulates, grizzly bears and black bears using a golf course, especially in the winter (ungulates) and early spring (ungulates and bears) for foraging. Cougars, wolves and coyotes might be attracted to the increased prey base. These species have all been observed hunting on golf courses situated in a wilderness context. However, deer, cougar, wolves, coyote and bears are dependent upon a sufficient amount of cover for hiding, resting. Cougar also use cover for stalking and hunting prey species. A golf course that removes too much cover will certainly displace many of these species, regardless of the enhanced forage. Forest carnivores, such as the lynx, fisher and marten will also be affected by the removal of cover. These forest carnivores are habitat specialists and depend upon specific forest seral stages and structure for survival. A golf course increases open space and edge habitat, which favours generalist species such as the coyote. These species may out compete and even kill forest carnivores. A golf course that removes forest habitat is in direct conflict with these species needs and reduces the habitat effectiveness of the area for forest carnivores.

For wildlife species that may benefit from or tolerate habitat alteration from a golf course, their ability to use a golf course may be compromised due to their intolerance of humans or vice versa. A golf course is associated with an increase in human presence, especially during the golfing season. Species that are notably sensitive to human presence include the grizzly bear, wolf and wolverine. These species are likely to be displaced as human use of an area increases. In addition ungulate populations that are hunted or that have not had previous exposure to humans may be initially displaced. Displacement may have negative impacts on populations if the area represents the last vestiges of important habitat or corridors or if the species are displaced from habitats considered sensitive. For example, ungulates and bears are sensitive during the early spring and are most vulnerable to stresses and loss of prime foraging during this time. Most species, however, such as black bears, coyote, elk, deer, bighorn sheep and possibly some wolves and grizzly bears may adjust over time to human presence through habituation. There is evidence of all these species using golf courses in various contexts and to varying degrees. Unfortunately there are very few studies that document the change in habitat use and movement prior to and post golf course development. Anecdotal observations may indicate use but do not provide a clear picture on the long-term compatibility of a golf course with wildlife. In addition, although habituation allows access to resources and habitat, it also increases the likelihood of individuals experiencing human-wildlife conflicts. These conflicts often result in translocation or removal of the animal from the population. There is evidence that grizzly bears, black bears, cougar and elk have been translocated off golf courses due to human-wildlife conflicts. There is also evidence that elk, deer and cougar have been removed from the population due to conflicts with humans and their attraction to associated developments.

A golf course has the ability to act as a movement corridor for certain species but its use may be compromised by human presence and golf course context. Most of the wildlife species considered in this report have large home ranges and are dependent upon lower valley bottoms for dispersal or for moving between habitat patches. Movement through a golf course may be important in preventing habitat fragmentation and isolation of populations. Fragmentation can increase the possibility of inbreeding, can alter predator-prey dynamics and can result in the loss of mate choice and/or food resources. The ability of wildlife to move through an area will vary depending upon the golf course context, the level of human presence and the habituation of the wildlife species. A golf course associated with human developments, such as a housing settlement, will have less travel route and habitat options available to it. In addition there will be more humans in the area, increasing the likelihood of human-wildlife conflicts and displacement through management action. Wildlife may adjust to human presence by shifting their activity patterns to night. Although this allows less habituated wildlife to move through an area it also results in decreased habitat effectiveness because they are temporally restricted. In addition, wildlife, such as bears, cougars and elk do not recognize areas strictly as movement corridors and they may stay in the area if human attractants are nearby. This again increases the likelihood of human-wildlife conflicts and subsequent displacement through management action.

The context of the golf course is an important aspect in evaluating the potential impact of a golf course. In the Rocky Mountains, golf course development tends to be located in lower valley bottoms which also represent habitat and movement corridors for many wildlife species. A golf course in a developed landscape has less travel routes and habitat options available to wildlife. In this context a golf course placed in a critical movement corridor or habitat patch will negatively impact wildlife. The golf course will likely displace some or all species through their own sensitivity or through management actions. In addition it may restrict temporal access and act as a barrier to movement during high period of human use. Wildlife displaced in this context may have no habitat alternatives. The golf course, therefore, must be assessed in relation to its context in association with other developments on the landscape as well as its importance as a corridor or habitat patch to wildlife in the region.

Golf courses have received criticism in regard to their impact on the landscape and wildlife and because of their poor management practices (Von Schuckmann, 1994). Some of the potential impacts can be avoided in the design phase. The corridors and patches critical to wildlife habitat should be maintained and protected from development. Course layout should reflect the needs of wildlife and designed to meet the needs of an assortment of species. All golf courses should have a wildlife management plan that highlights how the golf course will co-exist with wildlife (BC Environment, 1994). It should outline aversive conditioning techniques and should highlight whether they will accept wildlife based upon the season. The plan should include a monitoring program that assesses the ongoing relationship between the golf course and wildlife. Examples found of mitigation activities in the Rocky Mountains generally included activities that displaced wildlife from the golf course such as fencing or aversive conditioning techniques. These activities may not be appropriate if wildlife are dependent upon the golf course for movement or habitat. Design mitigation activities that would not displace wildlife include maintaining cover and buffer zones between the fairways, leaving snags, buffering water bodies and maintaining linkages to forest refugia. Operational mitigations include reducing daily golfing hours, introducing periodic closures for certain species, implementing human access management measures in the off season and securing conservation easements on adjoining lands. However, even with all of these measures included, the simple increase in human presence, which a golf course draws, is very difficult to completely mitigate. A golf course's economic objectives are to maximize human use and this is fundamentally at odds with the needs of most wildlife.

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Jury, Doug. Wildlife Biologist. British Columbia Department of Environment, Lands and Parks, British Columbia.

Krebs John. 2000. Senior Wildlife Biologist, Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC Environment Lands and Parks, British Columbia.

Limke, Tom. 2000. Area Biologist. Montana Fish, Wildlife and Parks, Montana.

Manley, Tim. 2000. Grizzly Bear Specialist for NW Montana, Montana Fish Wildlife and Parks, Montana.

Mattson, Dave. 2000. Senior Wildlife Research Biologist, U.S.G.S., Colorado.

McLellan, Bruce. 2000. Senior Wildlife Habitat Ecologist, British Columbia Ministry of Forest, British Columbia.

Monnello, Ryan. 2000. Natural Resource Specialist, Rocky Mountain National Park, Colorado.

Olson, Gary. 2000. Wildlife Biologist, Conard. Montana Fish Wildlife and Parks, Montana.

Pattison, Kevin. 2000. Superintendent, Banff Springs Golf Course, Alberta.

Paquet, Paul. 2000. Associate Professor, University of Calgary, Alberta.

Reynolds, Daryl. 2000. Wildlife Biologist, BC Environment Wildlife Division, Sunshine Coast, British Columbia.

Spowart, Rick. 2000. District Wildlife Manager, Rocky Mountain Region, Colorado Division of Wildlife, Colorado.

Swan, Bill. 2000. Osprey Communication, Radium Hot Springs, British Columbia.

Van Tighem, Kevin. 2000. Manager Ecosystem Services, Jasper National Park, Alberta.

Waite, Scott. 2000. Terrestrial Wildlife Biologist, Colorado Division of Wildlife, Colorado.

Watt, Rob. 2000. Wildlife Warden, Waterton Lakes National Park, Alberta.

Weneum, Erik. 2000. Wildlife Conflict Specialist, Montana Department Fish, Wildlife and Parks, Montana.

APPENDIX A: *Search Documentation*

Published Literature

Primary Search

The following search words were used for all searches outlined below:

Keywords used: Golf courses, golf, wildlife corridors, development, grizzly bear, landscape pattern, fragmentation, vegetation patterns, buffer zones, Bow Valley, elk, birds, small mammals, carnivores, ungulates, golfing, recreation, disturbance, habitat alterations, human disturbance, resort, ecosystems, conservation, wildlife conservation, nature conservation, landscape connectivity, impact assessments, Bow Valley corridor.

Combinations of search words: Wildlife and golf courses, wildlife and development, wildlife and disturbance, wildlife and recreation, ungulates and development, carnivores and disturbance, ungulates and disturbance, carnivores and development, ungulates and recreation, carnivores and recreation, fragmentation and carnivores, fragmentation and ungulates, conservation and golf, conservation and wildlife, landscape connectivity and golf, impact assessments and golf, corridors and impact assessments, corridors and ungulates, corridors and wildlife, corridors and carnivores, corridors and conservation.

Electronic database searches form University of Calgary:

CARL: Indexes articles from some 17,000 journals in all disciplines.

Biological Abstracts: Abstracting and indexing reference publication that includes bibliographic references with abstracts derived from life sciences research journals published worldwide.

Canadian Research Index: Provides citations and abstracts for publications issued by the federal government and the governments of the ten provinces and three territories, including policy papers, statistical reports, annual reports, and research papers.

Environmental Abstracts: Contains citations and abstracts to journal articles, conference papers, and other publications covering all aspects of human and technological impact on the environment. Environment Abstracts is available through a joint initiative with the University of Alberta.

Proquest: Indexes doctoral dissertations and master's theses worldwide. Contains bibliographic citations and dissertations for doctorate and masters thesis from 1861 to the present. The database covers more than 1 300 000 and is linked into the National Library of Canada dissertation database.

Wildlife Worldwide: Index to the global literature on wild mammals, birds, reptiles, and amphibians. All aspects of wildlife and wildlife management are covered. Databases licensed from: NISC USA (National Information Services Corporation), The Swiss Wildlife Information Service, BIODOC, and the U.S. Fish & Wildlife Reference Service

Library card catalogues:

University of Calgary Library: Books and reports relevant to the issue.

Faculty of Environmental Design Library: Searched library for relevant master's theses and 702 projects.

Electronic database searches from the internet:

GATE: The Alberta Environment Library contains more than 57,000 books, reports, government documents, videos, maps, periodicals, and annual reports. The collection covers a wide range of topics about the environment, including air quality, conservation, ecology, environmental engineering, environmental impact assessments, environmental law and legislation, fisheries, forestry, natural resources, oil sands, parks, waste management, water resources, and wildlife. The Library's collection is available for use by department staff, industry, academia, other government agencies, and members of the public. ***(http://www.gov.ab.ca/env/info/library/index.html)***

Effects of Recreation on Rocky Mountain Wildlife Online Bibliography: is a comprehensive bibliographic database on the effects of motorized and non-motorized recreation on wildlife and wildlife habitats, focusing on free-ranging wildlife species in Montana. The bibliography is a compilation of references that address the effects of recreation and disturbance on species of amphibians, reptiles, birds, and mammals (excluding bison). Select papers that provide important background information on species' behavior, physiology and habitat requirements are also included.
(***http://montanatws.org/pages/page4b.html)***

WSU Libraries- Washington State University: Scientific Research and Science in Yellowstone National Park is a Web-searchable bibliographic database of nearly 10,000 citations to scientific journal articles, books, proceedings, abstracts, videos, dissertations and theses, raw data, reports, letters and manuscripts dealing with Yellowstone National Park.
(http://www.wsulibs.wsu.edu/ris/risweb.isa)

Internet search engines

We used the following search engines, Excite, Alta Vista, MSN, Web Crawler, Canada.com, Lycos and Northern Light using the above listed keywords.

Useful internet sites:

http://www.threesisters.ca/environment.html: Environment page for Three Sisters Golf Course.

http://www.golfdesign.org/regular/enviro: American Society for Golf Course Architects, listing of principals and guidelines for designing golf courses that function with the environment.

http://wildlife.state.co.us: Colorado Department of Wildlife, Issues relating to wildlife in Colorado and contact information.

http://www.gov.ab.ca/nrcb/index.html: Natural Resource Conservation Board, has environmental impact assessments on line.

http://www.worldweb.com/VertexCustomers/p/ParksCanada-Banff/corridor.html: brief description by Parks Canada on wildlife corridors.

http://www.rtj2.com/company.htm: golf course architectural firm that has designed golf courses based on the USGA standards.

http://gcsaa.org/resource/environ/envirprin.html: environmental principles for golf.

http://www.audubonintl.org/acss/golf.htm: Audubon International Cooperative Sanctuary Program for Golf.

http://www.fs.fed.us/r1/planning/lynx: Lynx information from the USDA Forest Service.

http://www.fs.fed.us/pnw/pubs/gtr_420.pdf: Carnivore needs in the Columbia Basin.

Golf magazines online:

http://www.golfonline.com/: has a few articles on 'green' golf.

http://www.golfjournal.com/: Official publication of the United States Golf Association.

http://www.gcsaa.org/gcm/gcm_fr.html: Golf Course Management Magazine.

http://www.ngf.org/: good links to publications about golf and the environment.

Journals on line:

The following were searched in conjunction with Paul Paquet with the search terms "golf" and "wildlife":
Journal of Wildlife Management
Transactions of North American Natural Resources Conference
Ecological Society of America's Database
Journal of Mammalogy
Canadian Journal of Zoology
Conservation Biology
IBIS
Ornithological Society of North American database

Books on line:

Sleepingbearpress.com:

This site has a number of relevant books of which we have ordered two.
Scott Gillihan 'Bird Conservation on Golf Courses'
Ronald Dodson 'Wildlife Habitats on Golf Courses'

Golf Course environmental books:

Love, William R., ASGCA American Society of Golf Course Architects (1999) An Environmental Approach to Golf Course Development

The National Golf Foundation (1999) Environmentally Friendly Golf Courses (Second Edition)

Contact information on line: for researchers, gold course superintendents and government were obtained from the internet.

Secondary Search

All information gathered was read and then a secondary search was performed on the references high-lighted as useful.

Unpublished Material (Personal communication)

Miistakis contacted the following types of individuals for anecdotal evidence (the majority of information was generated from personal communication)

Professors and Graduate students from Universities

Golf Course Superintendents

Private Consultants: Bow Valley and Calgary area.

Wildlife Biologists/District Managers

Government Representatives

APPENDIX B: *Guidelines for Personnel Communications*

For the different type of individuals contacted, questions were developed to ensure consistency. The questions varied depending on the person's area of expertise and experience the questions varied.

Golf Course Researchers

- Describe your research.
- What are the objectives?
- Have there been any past studies?
- When will results be published?
- Do you have any published literature?
- Summary of findings.
- Contact information for other researchers in the same field.

Wildlife Biologists/ District Wildlife Managers

- Do you have experience with wildlife and golf courses?
- Which species have you seen using golf courses?
- Describe location and surroundings of the golf courses (level of development)
- Is the golf course in critical wildlife habitat or a wildlife corridor?
- What are the management issues associated with species using the golf course.
- Describe mitigation measures for dealing with problem wildlife.

Golf Course Superintendents

- Detail golf course location and surroundings? (Is the golf course surrounded by development?)
- Have there been any studies done on the use of the golf course to assess the impacts on wildlife? (Get details on studies, monitoring programs).
- How does your golf course maximize wildlife habitat? Describe mitigation measures implemented to benefit wildlife.
- Do large carnivores/smaller mammals use the golf course? At what times of the day and in which season?
- Do ungulates use the golf course? What problems are associated with ungulate using the golf course?

Appendix B: ***Contacts***

Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Martin Jalkotzy		Arc Wildlife Services Ltd.			Yes	Craig Stewart	Cougar anecdotal observations	Alberta
Stan Hawes	Fish and Wildlife Officer	Alberta Environment	403-932-2388		No	Mike Gibeau	Ph.D. Thesis on Grizzly Bears	Alberta
Richard Bryant	Conservation Officer	Alberta Environment	403-932-2388		No	Jon Jorgenson		Alberta
Dave Hannah	Conservation Officer	Alberta Environment	403-591-6300		No	Jon Jorgenson		Alberta
Kirby Smith-Bio		Alberta Environment, Edson			Yes	Jon Jorgenson	No information on wildlife and golf courses	Alberta
Clayton Apps	Researcher	Aspen Consulting	403-270-8663		Yes	Jon Jorgenson	Lynx / bobcat researcher	Alberta
Kirk Strom		AXYS	403-750-7651	kstrom@axys.net	Yes		Trying to get Peter Balagus's reports	Alberta
Peter Balagus	Consultant in Canmore	AXYS	403-750-7652		no	Frank Kernick	Requesting tracking reports for Eagle Terrace	Alberta
Kevin Pattison	Superintendent	Banff Springs Golf Course	403-762-6869		Yes	Scott Martin	Details on the steps taken at the Banff Springs Golf Course to benefit wildlife.	Alberta
Melanie Watt	Director	Biosphere Institute of the Bow Valley	403-678-3445		Yes	Frank Kernick	Information on golf	Alberta
Rocky Hornung		Bow Valley Provincial Park	403-673-3663		Yes	Jon Jorgenson	Wildlife issues associated with the Kananaskis golf course	Alberta
Danah Duke	Masters Thesis	Canmore	403-678-2678		Yes	Jon Jorgenson	Anecdotal evidence of species use and avoidance of golf courses	Alberta
Jake Herrero	Consultant in Canmore	Canmore	403-678-1903		Yes	Bart Robinson	Suggestion of contacts	Alberta

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Carolyn Callaghan	Wolf Researcher	Canmore	403-678-9633		Yes	Paul Paquet	Anecdotal information from field work in regards to wolves and golf courses.	Alberta
Frank Kernick	Developer	Eagle Terrace Developer	403-609-3714		Yes	Jon Jorgenson	Given us permission to view Axys reports on Eagle Terrace Development	Alberta
Dr. M. Gibeau	Senior Researcher	Eastern Slopes Grizzly Bear Project	403-678-6513	mike_gibeau @pch.gc.ca	Yes	Craig Stewart	Given us a copy of his thesis which has a section on the sensitivity of grizzly bears to human presence.	Alberta
Harry Stelfox	Provincial Wildlife Specialist	Government of Alberta	780-427-2044	harry.stelfox @gov.ab.ca	Yes	Craig Stewart	Annotated literature review on ungulates done	Alberta
Wes Bradford	Wildlife Biologist	Jasper National Park	403-852-6204		Yes		Suggested we call Brenda Dobson (trying to get EIA	Alberta
Brenda Dobson	Park Warden	Jasper National Park	780-852-6232	brenda_dobs on@pch.gc.c a	Yes	Perry Cooper	Incharge of environmental surveillance and wildlife monitoring on the Jasper golf	Alberta
Perry Cooper	Grounds Manager	Jasper National Park Golf Course	780-852-3301 ext 6086		Yes		Info on golf course mitigation practices and how they are altering the course for	Alberta
Dave Dalman		Parks Canada	403-762-1550	dave_dalma n@pch.gc.ca	Yes	Jon Jorgenson	Danah Dukes contact and three sisters environmental	Alberta

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Tony Clevenger		Parks Canada	403-760-1371	tony_clevenger@pch.gc.ca	No	Jake Herrero		Alberta
James Beebe	Superintendent	Priddis Golf Course and Country Club	403-931-3391		No	Scott Martin		Alberta
Lou Kamenka	Consultant in Canmore	Three Sisters Resort	403-678-5142		Yes	Dave Dolman	Information on tracking activities on Three Sisters Property post and prior golf course	Alberta
Tom Atkinson	Developer	Three Sisters Resort	403-974-0450		Yes	Jon Jorgenson	Contact for Lou Klemenka, tracking wildlife through the golf	Alberta
Luigi Morgantini	Professor	University of Alberta		luigi.morgantini@ualberta.ca	No		Ungulate specialist	Alberta
Dianne Draper	Professor	University of Calgary	220-5584	draper@ucalgary.ca	Yes		Active in bow valley corridor	Alberta
Paul Paquet	Associate Professor	University of Calgary		ppaquet@sk.sympatico.ca	Yes	Craig Stewart	Quotes on species use of golf course and a search of databases for	Alberta
Rob Watt	Wildlife Warden	Waterton Lakes National Park		RA_Watt@pch.gc.ca	Yes			Alberta
Darly Renolyds	Wildlfie Biologist	BC Environment Wildlife Division	604-740-5036		Yes		Elk anecdotal	BC
Daryl Renyolds	Wildlife Biologist	BC Environment, Wildlife Section, Sunshine Coast	604-740-5036		Yes	Dave Dunbar	Big elk problems with golf course, have been translocated and hunted to reduce	BC
Dave Dunbar	Wildlife Biologist	BC Environment, Wildlife Section, Surrey	604-582-5215		Yes	Internet search on BC environment	Contact info for individuals working near Golf Courses and	BC

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Mark Pimlote	Wildlife Technician	BC Environment, Wildlife Section, Surrey	604-582-5294		Yes	Dave Dunbar	Whistler not an issue because it's in a mountain pass and not in the lower valley bottom. No prior	BC
Larry Ingham	Wildlife Biologist	BC MELP	250-342-3941		Yes	John Gwilliam	Suggested we contact Bill Swan	BC
John Gwilliam	Wildlife Biologist	BC MELP	250-352-6874		Yes		Suggested we contact Larry	BC
Doug Jury	Wildlife Biologist	BC MELP (Kamloops)	250-371-6264		Yes	BC Government Directory		BC
Sylvia Von Schuckmann	Wildlife Biologist	BC MELP (Kamloops)	250-387-9557		Yes	Marcel Demers	Information on guidelines developed for golf courses and	BC
Don Doyle	Wildlife Biologist	BC MELP (Nanaimo)	250-751-3219		No	BC Government Directory		BC
Kim Brunt	Wildlife Biologist	BC MELP (Nanaimo)	250-751-3213		Yes	BC Government Directory	Suggested we contact Marlene	BC
Marlene Kaskey	Habitat Technician	BC MELP (Nanaimo)	250-751-3220		No	Kim Brunt		BC
Bob Lincoln	Wildlife Habitat Biologist	BC MELP (Penticton)	250-490-8254		No	BC Government Directory		BC
Glen Watts	Wildlife Biologist	BC MELP (Prince George)	250-565-6426		Yes	BC Government Directory	No real issues because the only golf course is in the center of town and no wildlife use	BC
Rick Marshall	Wildlife Biologist	BC MELP (Smithers)	250-847-7274		Yes	BC Government Directory	Fox eat golf balls, all other animals use the course to travel through, wilderness context	BC
Jim Young	Wildlife Biologist	BC MELP (Williams Lake)	250-398-4564		Yes	BC Government Directory	Suggested contacting call	BC

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Marcel Demers	Wildlife Biologist	BC MELP (Williams Lake)			Yes	BC Government Directory	Suggested contacting Sylvia VonSchuckmann	BC
John Youds	Wildlife Biologist	BC MELP (Williams Lake)	250-398-4563		No	BC Government Directory		BC
Bruce Mclellan	Senior Wildlife Habitat Ecologist	BC MOF	250-837-7767	bruce.mclellan@gems9.gov.ab.ca	Yes		General anecdotal evidence of golf course use (not much info).	BC
Aspen Grove Golf Course		British Columbia	780-963-9650		Yes	Jake Herrero	Possibley have ecologist/biologist on staff	BC
Bert Mcfadden	Superintendent	Chateau Whistler Golf and Country Club	(604) 938 4912		Yes		No knowledge of any biological information	BC
John Krebs	Wildlife Biologist	Columbian Basin Fish and Wildlife Compensation Program, Nelson, BC Environment Lands and Parks.	250-352-6874		Yes	BC Government Directory	Information on wolverine habitat preference.	BC
Bob Forbes	Regional Wildlife Section Head	Ministry of Environment, Lands and Parks	(250) 489 8547	bob.forbes@gems9.gov.bc.ca	Yes		Personal communication re effects on wildlife, noted by himself and area biologist Doug Martin, on Golf courses in the Rocky	BC
Bill Swan	Consultant in Radium	Osprey Communication	250-342-3357	osprey@rockies.ca	Yes	Larry Ingham	Bighorn in our Backyard	BC

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Frank Vargas	Superintendent	Point Grey Golf and Country Club	604-263-5444		Yes	Scott Martin	Golf course certified by Audobon society. Grasses planted are "diverse," and palatable to a wider audience of animals. No knowledge of any studies before or after the use of	BC
Maureen Garland	Director Continuing Education and Communications	University of British Columbia	604-822- 5072		Yes	Janet Mackay	Integrated pest management, "naturalization" of turf grass, "naturalizing managed turf	BC
Bob Whick	Executive Director	Western Canada Turf Grass Association	604-467-2564		Yes		Encourages the use of diverse grasses by	BC
Scott Martin,	Director	Audubon Cooperative Sanctuary System of Canada	705-429-2277	acss@cois.on.ca	Yes	Jean Mackay	List of golf courses that are certified by Acssc in Canada	Canada
Glenn Barrett		Environment Canada	905-336-4952	glenn.barrett@gov.ab.ca	Yes	Dave Gordon	Starting study next year on water quality and animal use of golf courses. Mailing	Canada
Dave Morrison	Grad Student	Ontario	416-391-2322 ext231		Yes	Craig Stewart	Emailing list of references	Canada
Francis Singer	Research Biologist	USGS Mid-continent Ecological Science Center	970-491-7056	frank@nrel.colostate.edu	No	Ryan Monnello		Colorado
Aspen Golf Course		Colorado	970-704-1988		Yes	Jake Herrero		Colorado

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Scott Gillihan		Colorado Bird Observatory	303-659-4348	scott.gillihan@cbobirds.org	Yes	Wildlife Links	Written a book: "Bird Conservation on	Colorado
Dave Fraddy	Elk Research Biologist	Colorado Division of Wildlife	970 272-4346		Yes	Ken Hamlin	Contact info for Colorado Biologists	Colorado
Janet George	Wildlife Biologist	Colorado Division of Wildlife	303-291-7332		Yes	Dave Fraddy	No information but suggested contacts for area biologists that work around golf	Colorado
Ric Spowart	District Wildlife Manager, Estes	Colorado Division of Wildlife	970-667-2984		Yes	Dave Fraddy	Experience with ungulate and cougar on golf	Colorado
Bill Andree	District Wildlife Manage, Vale	Colorado Division of Wildlife	970-947-2932		Yes	Dave Fraddy	Experience with elk and deer on golf courses.	Colorado
Scott Waite	Wildlife Biologist	Colorado Division of Wildlife	970-382-6645		Yes	Dave Fraddy	Black Bears and pine marten info.	Colorado
Bob Davies	Wildlife Biologist	Colorado Division of Wildlife	719-227-5225		Yes	Dave Fraddy	Golf courses elk, deer and cougar	Colorado
David Cooper	Research Scientist	Colorado State University	970-491-6109		No	Jeff Connor	Research on the reclamation of golf course (hydrology focused)	Colorado
Robert Auckerman	Professor, Natural Resource and Recreation	Colorado State University	970-491-5511		No	Ken Czarnowski		Colorado
Dr.Alldredge	Professor	Colorado State University	970-491-5520	billal@picea.cnr.colostate.edu	Yes	Bill Andre	Elk research	Colorado
Ryan Monello	Elk Researcher	Rocky Mountain National Park		ryan_monello@nps.gov	Yes	Jeff Connor	General info about elk	Colorado
Jeff Connor	Natural Resource Specialist	Rocky Mountain National Park	970-586-1296		Yes	Dick Putney	slightly more specific info on effects of closing	Colorado

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Ken Czarnowski	Research Administrator	Rocky Mountain National Park	970-586-1263		Yes	Katie Sykes	General info about elk	Colorado
Katie Sykes	Admin Assistant, Resource Management Division	Rocky Mountain National Park	970-586-1297		Yes	Dick Putney	General information and phone numbers for other contacts	Colorado
Dick Putney	Rocky Mountain National Park employee	Rocky Mountain National Park	970-586-1206		Yes	Paul Paquet	General park info about closure of golf course	Colorado
Dave Mattson	Senior Wildlife Research Biologist	USGS, Colorado	520-556-7466 ext 245	david.mattson@nau.edu	Yes		Grizzly bear information	Colorado
Mike Kinziger	Principal Scientist	Idaho Wilderness Research Center	208-885-2165	mikek@uidaho.edu	No			Idaho
Jason Karl	GIS Analyst	University of Idaho		jason@artemisia.wildlife.uidaho.edu	No		Habitat-wildlife relationships	Idaho
Gerald Wright	Professor	University of Idaho	208-885-7990	gwright@uidaho.edu	No		Ungulates	Idaho
Ben Conard	Wildlife Biologist	Beaverhead National Forest, Dillon	406-683-3900		Yes		Information on fisher, marten, wolverine and lynx	Montana
Dan Carney	Wildlife Biologist	Blackfeet Tribal Office	406-338-7207		Yes	Gary Olson	East Glacier Golf Course and bears	Montana
Tom Whittinger	Wildlife Biologist	Flathead National Forest, Kalispell	406-758-5200		Yes	Effects of Recreation on Rocky Mountain Wildlife	Information on Grizzly bears and golf courses and translocations. Contact info.	Montana
Micheal Hillis	Forest Wildlife Biologist	Lolo National Forest, Missoula	406-329-3750		Yes	Effects of Recreation on Rocky Mountain Wildlife	General info but does not have much experience	Montana
Erik Weneum	Wildlife Conflict Specialist	Montana Fish, Wildlife and Parks			Yes	Carolyn Sime	Wildlife issues associated with Golf Course.	Montana

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Tom Lemke	Area Biologist	Montana Fish, Wildlife and Parks	406-222-0102		Yes	Ken Hamlin	Information on a golf course development and design around Yellow Stone	Montana
Tim Manley	Grizzly Bear Specialist for NW Montana	Montana Fish, Wildlife and Parks	406-751-4584		Yes	Tom Wittinger		Montana
Kevin Coats	Area Biologist	Montana Fish, Wildlife and Parks, Kalispell	406-751-4582		Yes	Heidi Youman		Montana
Micheal J. Thompson	Wildlife Management Biologist	Montana Fish, Wildlife and Parks, Missoula	406-542-5523		Yes	Effects of Recreation on Rocky Mountain Wildlife	No information but gave us contacts to follow up on.	Montana
Ken Hamlin	Research Biologist	Montana Fish, Wildlife and Parks, Missoula	406-944-6365		Yes	Micheal J Thompson	Contact names for biologist working around golf courses and in	Montana
Neil Anderson	Wildlife Biologist	Montana Fish, Wildlife and Parks, Missoula	406-994-6357		yes	Effects of Recreation on Rocky Mountain Wildlife	Information on coyotes and foxes on golf courses.	Montana
Gary Olson	Wildlife Biologist	Montana Fish, Wildlife and Parks,Conrad	406-278-7033		Yes	Effects of Recreation on Rocky Mountain Wildlife	Contacts in Montana	Montana
Heidi Youmans	Wildlife Biologist	Montana Fish, Wildlife and Parks,Helena	406-444-2612		Yes	Effects of Recreation on Rocky Mountain Wildlife	Contact information, no information for her experience.	Montana
Joe Ball	Director, Montana Cooperative Wildlife Research Group	University of Montana	406 243 5372		Yes	Ron Dodson	No information but suggested we look at the Effects of recreation on Rocky Mountain Wildlife report.	Montana

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Name	Title	Organization	Phone number	E-mail	Response	Contact Source	Description	Country/ Province
Carolyn Sime	Wildlife Biologist		406-751-4586		Yes	Gary Olson	Urban development and wildlife and	Montana
Denis Griffiths	Past President	American Society of Golf Course Architects	770-867-4480		No	Web Page		USA
Dr. William Shaw	Professor	Arizona State		william_shaw@ns.arizona.edu	No	Scott Martin	Organized an Urban Wildlife Symposium in	USA
Jean Mackay	Education Director	Audubon Cooperative Sanctuary System		jmackay@audbonintl.org	Yes	Ron Dodson	Details on bird monitoring program and list of individuals to	USA
Ron Dodson		Audubon International			Yes	Internet	Written a book: "Golf course and wildlife	USA
Dave Gordon	Professor	Clemson University	843-559-4762 (ext22)	david_gordon@fws.gov	Yes	Wildlife Links	Funding received for study on avian community response to golf	USA
Thomas Emmel	Professor	University of Florida	352-392-1137	tcemmel@ufl.edu	No	Wildlife Links	Received funding for study on corridor establishment for and endangered	USA
Jim Snow	Director	USGA Green Section		jsnow@usga.org	No	Ron Dodson		USA
Dr. L. Woolbright	Research Director	USGA Wildlife Links Program		lwoolbright@audobonintl.org	No	Ron Dodson		USA
Sharon Newsome	Environmental Program Director	Physicians for Social Responsibility	202-898-0150	snewsome@psr.org	No		Golf critic since 1994	USA,
Steven Buskirk	Professor	University of Wyoming	307-766-5626	marten@uwyo.edu	Yes		lynx researcher/gave links to papers on lynx, marten,	Wyoming

APPENDIX C: *Birds and Small Mammals*

There have not been very many studies completed on golf courses by ecologists so their potential as wildlife reserves for smaller mammals and birds largely remains unknown. Although this literature review focused primarily on ungulates and large mammals, both small mammals and birds are also affected by golf course development. The current state of knowledge indicates that implementing natural landscaping on golf courses will do much more than conventional methods to improve the habitat of many birds and other wildlife (Terman, 1997).

Small Mammals

Although small mammals were not the focus of this literature review they are affected by golf course development and represent an important component of the ecosystem. Beaver and ground squirrels are usually considered nuisance species. Beavers cause flooding and cut down trees and the ground squirrels burrow on the fairways. These species are either trapped and relocated or are removed from the population by poisoning. In British Columbia the Yellow Badgers, is an endangered species have been adversely affected by golf course development. They have been observed ingesting ground squirrels that were poisoned and consequently died (Forbes, pers. comm.). Most small mammals can be easily accommodated by maintaining covered area, leaving snags and brush piles and providing higher grass patches for movement between fairways.

The following references pertaining to small mammals:

- Jodice, P.G.R & S. Humphrey. 1992. **Activity and diet of an urban population of Big Cypress Fox Squirrels**. Journal of Wildlife Management. 56(4):685-692.
  The Big Cypress fox squirrel is listed as endangered by the state of Florida. Individuals are secretive and their biology is poorly unknown. However, populations in urbanizing areas persist on golf courses, where they are protected, habituated to humans, and readily observed. These populations offer opportunities to study and promote the survival of the subspecies. Consequently, we studied activity and diet of Big Cypress fox squirrels for 1 year on 4 golf courses in Naples, Florida.

- Jodice, P.G.R & S. Humphrey. 1992. **Activity and diet of an urban population of Big Cypress Fox Squirrels: A Reply**. Journal of Wildlife Management. 57(4):930-933.
  They reiterate that golf-course squirrels present an opportunity for conserving wildlife, promoting favorable land use, and engaging a pro-wildlife constituency, and they argue for seizing conservation opportunities wherever they occur, whether in urban or native context.

- Tischendorf, L & C. Wissel. 1997. **Corridors as conduits for small animals: attainable distances depending on movement pattern, boundary reaction and corridor width**. OIKOS. 79: 603-611.
  Corridors are supposed to facilitate and conduct moving individuals between habitat remnants within an otherwise inhospitable landscape. they present hypothetical answers to this problem based on simulations of individual movements through corridors.

Birds

Of all the species considered in this review birds have the most literature accessing the impacts on golf course on their habitat. Information for this section was obtained from an annotated bibliography prepared by Scott Gillihan of the Colorado Bird Observatory.

- Askins, R.A. 1994. **Open corridors in a heavily forested landscape: impact on shrub-land and forest-interior birds.** Wildlife Society Bulletin. 22:339-347.
  Recommends consolidating open areas [could be interpreted to include fairways] to preserve as much forest interior as possible.

- Askins, R.A., & M.J. Philbrick. 1987. **Effect of changes in regional forest abundance on the decline and recovery of a forest bird community**. Wilson Bulletin. 99:7-21.
  Looked at changes during the period 1953-1985. 7 of 8 species that were lost by 1976 were long-distance migrants. In general, populations of forest-interior species declined from 1953-1976. Populations of "suburban" species were not correlated with regional forest abundance [suburban species are "species that are common in edge habitat and wooded residential areas"]. Trends in abundance of suburban species were generally opposite to those of forest-interior species, suggesting competition or some other negative impact of suburban birds on forest-interior species.

- Bechard, M.J. & J.M. Bechard. 1996. **Competition for nest boxes between American Kestrels and European Starlings in an agricultural area of southern Idaho.** Pp. 155-162 In: D.M. Bird, D.E. Varland, and J.J. Negro, eds. <u>Raptors in human landscapes: adaptations to built and cultivated environments.</u> Academic Press, London.
  Kestrels will use "athletic fields, cemeteries, city parks" p. 155Box occupancy averaged nearly 100%. Kestrels can out-compete starlings: during the first year the kestrel-to-starling proportion was 0.5:0.5, the second year 0.72:0.28, the third year 0.8:0.2, then in years 4-7 there were no starlings.

- Beissinger, S.R., & D.R. Osborne. 1982. **Effects of urbanization on avian community organization.** Condor. 84:75-83.
  Compared bird communities in town (Oxford, OH) with those found in a nearby state park. Forest canopy in town was lower, less developed than in the park; the lower vegetation strata (0.5-3 ft) much better developed in the park (7× as much coverage). Also, vegetation in town tended to be in isolated clusters, while it was more continuous in the park. Total vegetation volume was much lower in town. Found more individuals but fewer species in town. Guilds found in lower numbers in town included canopy-gleaning and bark-drilling insectivores, while ground-cleaners were found in higher numbers. Omnivores and carnivores were generally more

- Blake, J.G.& J.R. Karr. 1984. **Species composition of bird communities and the conservation benefit of large versus small forests**. Biological Conservation. 30:173-187.
  Woodlots surrounded by agricultural land in Illinois. Vegetation mostly similar across woodlot size, but even where it differs, "...forest area influences species richness ... to a much greater extent than does habitat structure." p.175
  "We conclude that two small forests may hold a greater total number of species, but that a single reserve will preserve more species that are most dependent on forest area." p.175
  "... long-distance migrants and forest-interior species were poorly represented in small forests and a single large reserve was more likely to support greater species totals for these groups." p. 173

- Cicero, C. 1989. **Avian community structure in a large urban park: controls of local richness and diversity.** Landscape and Urban Planning. 17:221-240.
  Compared five ponds in Golden Gate Park, San Francisco, CA (urban development on three sides, ocean on the fourth). Pond variables examined included size, average depth, % overhanging vegetation, plant species richness, indexes of habitat structure, distance to park boundary (i.e., to urbanization, generally). Bird species richness was positively correlated with local and peripheral habitat structure, and distance to park boundary. Recommendations: 1) Construct ponds as far from urban development as possible, and create an intervening buffer zone of "a complex and diverse mosaic of vegetation." 2) Ponds should be >2.5 ac. 3) "The shoreline should consist of shrubs or other low cover interspersed with bare ground and trees." 4) Shorelines should be irregular to maximize territory opportunities for riparian / transitional species. 5) Retain overhanging vegetation, and/or provide perches. 6) Retain snags, especially flooded snags. Alternatively, provide nest boxes.

- DeGraaf, R.M. 1986. **Urban bird habitat relationships: application to landscape design.** Transactions of the North American Wildlife and Natural Resources Conference. 51:232-248.
  Urban landscapes contain relatively few native species and many exotic species (and many are sterile varieties, thus offer no pollen or seeds or fruit), and woody vegetation is sparsely distributed instead of being clustered. "Landscape features such as woodlots—the bigger the better—open fields, relatively small lawn area and low building density are important to high bird species richness." p. 247

- Franklin, T.M. & L.W. Adams. 1980. **Bird response to habitat improvement in an urban environment.** Maryland Birdlife. 36:14-16.
  2.5-ac lot in downtown Baltimore, cleared of buildings and vegetation (except for a mature sycamore), and planted with ~2500 plants of six species known to attract birds (e.g., green-leaf barberry *Berberis thunbergi* and Autumn olive *Elaeagnus umbellata*). Total number of birds and species using the site increased.

- Gillihan, S. W. 1999. **Bird Conservation on Golf Courses: A design and management manual.** Colorado Bird Observatory, United States Golf Association, Ann Arbor Press, Chelsea, Michigan.
  This book is a hands on manual detailing how a golf course can be designed and managed to benefit birds. It has been written for golf architects and course superintendents. The material is primarily geared toward the habitat needs for songbirds, hummingbirds, woodpecker, raptors, shorebirds and wading birds. This book contains a detailed listing of habitat requirements for specific birds including structural needs and the area of patch size required for breeding.

- Kroodsma, R.L. 1984. **Effect of edge on breeding forest bird species**. Wilson Bulletin 96:426-436.
  Compared densities along a gradient from a powerline corridor into the forest interior (up to 480 m into the interior). Acadian Flycatchers and Ovenbirds were less abundant near edges—these species have been shown to be relatively intolerant of forest fragmentation. This study demonstrates that there is something about edges *per se* that the birds are avoiding (some structural difference, for example), rather than simple habitat loss. Some other species that are considered forest-interior species were not significantly less abundant near edges, suggesting that their negative response to forest fragmentation is due to patch size or isolation or some other factor.

- Lancaster, R.K. & W.E. Rees. 1979. **Bird communities and the structure of urban habitats**. Canadian Journal of Zoology. 57:2358-2368.
  Sampled birds and habitat features along a gradient of urbanization, from natural woodland to inner city. Bird species diversity and numbers of individuals were positively correlated with vegetation height diversity; bird species diversity decreased with increasing urbanization. The bird community in the two most urbanized settings was dominated by three exotic species (starling, House Sparrow, and Rock Dove accounted for >90% of the birds). Recommendations for urban bird management: design buildings that lack openings that could be used for nesting by exotic species; manage waste food disposal to eliminate it as a food source for exotic species; create more extensive and diverse vegetation plantings to create more habitat for native species.

- Maffei, E.J. 1978. **Golf courses as wildlife habitat**. Transactions of the Northeast Section of the Wildlife Society 35:120-129.
  "Some of the few and largest open and undeveloped areas left within urban areas are the private and public golf courses." p.120
  Diazinon: "There have been only small numbers of songbirds killed by this chemical since it has been used here. This occurred following direct feeding upon the treated insects." p. 128
  The country club covers 300 acres, of which 140 acres is golf course. They allow hunting, fishing, and trapping on the club property (but away from the course). Birdwatching is also allowed.

- Moul, I.E. & J.E. Elliot. 1994. **The bird community found on golf courses in British Columbia**. Northwestern Naturalist. 75:88-96.
  Water had the highest densities of birds, followed by hedgerows, trees, and turf. Compared with a bird survey done in nearby old-field hedgerows, the golf course had far more Northwestern Crows (a potential nest predator). Highest numbers and most species were found on courses with areas of unmaintained vegetation.
  "We encourage golf course designers and golf course superintendents to include pockets of undisturbed vegetation on golf courses." p. 95
  "From a golfer's perspective, minimal vegetation makes it easier to locate stray golf balls. The removal of ground vegetation, from the perspective of a bird feeding on turf, means the elimination of a place to retreat from predators or from perceived threats such as passing golfers." p. 93

- Saunders, D.A. & C.P. de Rebeira. 1991. **Values of corridors to avian populations in a fragmented landscape**. Pages 221-240 *in* Saunders and Hobbs, eds. Nature conservation 2: the role of corridors. Surrey Beatty and Sons, Sydney, Australia.
  Bird species that were dependent on remnant native vegetation (i.e., forest species) were more likely to be found in the wider corridors, and numbers of those species increased with increasing patch size. Based on mark-recapture data, the presence of corridors appeared to facilitate movement between patches (movement on the order of several kilometers). Suggest that corridors as narrow as 4 m can provide dispersal routes for some bird species.

- Terman, M.R. 1996. **The bird communities of Prairie Dunes Country Club and Sand Hills State Park.** USGA Green Section Record. 34(6):10-14.
  "Sensitive species" are more common on naturalized courses such as Prairie Dunes than on more traditional, highly manicured courses (based on his unpublished data). Birds that require larger areas and/or are less tolerant of human disturbance were more common in the park than on the golf course. The reverse was true for species with generalized habitat requirements and more tolerance of disturbance.

- Terman, M.R. 1997. **Natural Links: naturalistic golf courses as wildlife habitat**. Landscape and Urban Planning. 38: 183-197

- Yahner, R.H. 1988. **Changes in wildlife communities near edges.** Conservation Biology. 2:333-339.
  " ... we must not conclude that creation of more edge in landscapes will always have a positive effect on wildlife" in part because of increased nest depredation and cowbird nest parasitism near edges, and because of the loss of forest interior that usually accompanies edge creation (and thus contributes to loss of forest interior wildlife species).

References

Terman, M.R. Natural Links: Naturalistic Golf Courses as Wildlife Habitat. Landscape and Urban Planning, 1997. Vol.38: pp. 183-197.

APPENDIX D: *Future Research*

Despite the lack of information relating to golf courses and wildlife, many researchers are now identifying and analyzing relevant issues:

Large Mammals

- **Wildlife Movements Around Developed Areas in Banff National Park,** Alberta. Principal Investigator: Danah Duke, Masters Student, University of Alberta.

- **Wildlife Monitoring Program: Three Sisters Resorts**, Canmore, Alberta. Principal Investigator: Lou Klemenka.

- **Wildlife Monitoring Program: Jasper Park Golf Course**, Jasper, Alberta. Principal Investigator: Brenda Dobson.
  Beginning a 3-year monitoring project of wildlife on and around the golf course.

- **Wildlife Monitoring Program: Silvertip Golf Course**, Canmore, Alberta. Principal Investigator: Carolyn Callaghan.

- **Bighorn in Our Backyard: Osprey Communications.** Radium, British Columbia. Principal Investigator: Bill Swan.

Birds, Amphibians, Reptiles and Insects

The Wildlife Links Program represents golfs first comprehensive investigation of the games relationship with wildlife and its habitat. Among its goals are species habitat protection, environmental education, public-policy development, natural resource management, habitat and ecosystem rehabilitation and restoration, and leadership training for conservation professionals. It meets these goals by forging partnerships between the public and private sectors.

The USGA has eight projects that are relevant to wildlife on golf courses. They are being funded through the Wildlife Links Program.

- **Data Management System for Information on Wildlife Habitat on Golf Courses.**
  Principal Investigator: **Ronald Dodson**, Address: 46 Rarick Rd, Selkirk NY 12158, Tel: (518) 767-9051.
  A wealth of wildlife and habitat information is collected from golf courses participating in the Audubon Cooperative Sanctuary Program for Golf Courses (ACSP). This project is working to develop a computer-based system in which information gathered from participants in the ACSP can be efficiently accessed and utilized. With close to 950 species of birds, 600 species of reptiles and amphibians, and 100 species each of mammals and trees currently located at cooperating courses, a more efficient method of tracking this information is essential.

- **Golf Courses & Bird Conservation: A Management Manual.** Author: **Scott Gillihan** Address:13401 Piccadilly Rd Brighton, CO 80601, Tel: (303) 659-4348.
  This grant will result in a manual providing golf course superintendents with state-of-the-art information on habitat management for birds. Topics such as minimum habitat corridors, snag management, forage requirements, and enhancing habitat corridors will be covered. The habitat manual will be available in late 1998.

- **Wetlands Management Manual for Golf Courses**, Authors:**Don Harker & Gary L. Libby** . Address: 2071 River Circle, Richmond, KY 40475 Tel: (606) 527-0383.
  Wetlands management is one of the most important yet least understood land management topics facing golf course personnel. The *Wetlands Management Manual* will make understanding this topic less of a daunting task. The book will be an illustrated manual that uses a general overview to walk managers through understanding wetlands. This manual will help managers to conserve, create and restore, and better manage wetlands on their golf courses.

- **Amphibian Conservation on Golf Courses.** Principal Investigator: **Dr. James H. Howard**
  Address: Frostburg State University, Midlothian Rd Frostburg, MD 21532. Tel: (301) 687- 4168.
  Water hazards on golf courses might frustrate golfers, but they provide a valuable wildlife refuge. Many amphibians, especially frogs, use these areas as a source of food and nesting sites. Due to their highly permeable skin, frogs are sensitive to compounds in the environment. Dr. Howard is conducting field and laboratory investigations aimed at better design and management techniques of water features.

- **Conservation of Native Pollinators on Golf Courses**, Principal Investigator(s): **Melody Mackey Allen and Dr. Vince Tepedino.** Address: 4828 SE Hawthorne Blvd Portland, OR 97215 Tel: (503) 232-6639.
  Golf courses contain large areas that remain out-of-play and often unmanaged, providing habitat for plants and insects. These areas can be valuable for restoring populations of wildlife that help pollinate the surrounding plant life. Native pollinators, including native bees, butterflies and moths, have been on the decline in the last ten years. This project aims to develop better information on native plant pollinator habitat restoration.

- **Avian Community Response to Golf Courses**. Principal Investigator(s): **Dr. David H Gordon.** Address: Clemson University, G08 LeHotsky Hall, Clemson, SC. Tel: 803-559-4762.
  David Gordon is assessing the value of golf courses landscapes to avian communities. The results of the assessment will be used to produce a technical manual with management and design recommendations, as well as a brochure and color poster targeted at golf course stakeholder groups

- **Effects of Golf Course Construction on Amphibian Movement and Population Size:**
  Principal Investigator(s): **Dr. Peter Paton**, University of Rhode Island. Address: Lower College Road. Kingston, RI 0288, Tel: (401) 874-2986.
  Peter Paton is conducting a series of field experiments to investigate amphibian use of travel corridors, including the effects of turf on movement patterns and habitat selection. Data collected will be used to develop construction and management criteria for golf course managers which minimize the impact on amphibian movement patterns.

- **Corridor Establishment for an Endangered South Florida Butterfly.** Principal Investigator: **Dr. Thomas Emmel.** Address: University of Florida, 271 Grinter Hall Gainesville, FL 32611. Tel: (352) 392-0479.
  Dr. Emmel will work to restore and improve remaining tropical hardwood hammock habitat surrounding golf courses in the Florida Keys to increase breeding and corridor habitat for the endangered Shaus Swallowtail butterfly. Wild lime trees, which are the butterfly's larval host plant, along with other native adult nectar sources will be planted and butterfly populations will be monitored to detect new movement along the newly created corridor and new populations establishment

- **Golf Courses as Hotspots for Biodiversity in the Desert Southwest.** Principal Investigator: **Judy Perry.**
  Address: USDA Forest Service, Rocky Mountain Research Station 2205 Columbia SE, Albuquerque, NM 87106. Tel: (505) 766-1047.
  This project will investigate the distribution and abundance of birds and other wildlife on golf courses in the southwestern United State's Middle Rio Grande Valley. In addition, this project will investigate how golf course vegetation impacts wildlife habitat value, and will examine whether golf courses mitigate loss of other southwestern riparian zones.

- **Native Biodiversity and Golf Courses in Midwestern Landscapes**. Principal Investigator: **Dr. Robert Blair.** Address: Miami University, 212 Roudebush Hall Oxford, OH 45056 Tel: (513) 529-3190.
  This project will examine the conservation value of golf courses in Midwestern landscape by focusing on two indicator taxa: birds and butterflies. Specifically, this project will examine the landscape features that most benefit native species of birds and butterflies on golf courses and in adjacent habitats.

- **Burrowing Owl Conservation on Golf Courses**. Principal Investigator: **Dr. Courtney Conway**. Address: Washington State University, 2710 University Drive, Richland , WA 99352. Tel: (509) 375-4979.
  This project will install 150 nesting burrows for the declining Burrowing Owl on 5 golf courses in the Northwest. Burrow occupancy and reproductive success will be monitored to determine the types of locations on golf courses where Burrowing Owls can reproduce successfully. Results explaining how to install artificial will be distributed to golf course superintendents so that golf courses can contribute significantly to national recovery efforts.