SPATIAL OVERLAP BETWEEN HUMAN AND COYOTE (*Canis latrans*) ACTIVITY IN CAPE BRETON HIGHLANDS NATIONAL PARK OF CANADA

by

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled "SPATIAL OVERLAP BETWEEN HUMAN AND COYOTE (*Canis latrans*) ACTIVITY IN CAPE BRETON HIGHLANDS NATIONAL PARK OF CANADA" by Kate Porter in partial fulfilment of the requirements for the degree of Master of Environmental Studies.

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Abstract

Human-coyote conflict has intensified in Nova Scotia, following a fatal attack in Cape Breton Highlands National Park of Canada (CBHNPC) in October, 2009. This conflict has impacted people and coyotes across the province, and raised numerous questions about how humans and coyotes relate to one another and what steps we might take to avert future conflict. From 2011-2012, I used scat, remote camera, and snow tracking surveys to assess the degree of spatial overlap between human and coyote activity in CBHNPC. I found a negative correlation between hiker/biker and coyote activity in the summer and fall [$r=-.830$, $n=14$, $p<.01$]. In the winter, I found no correlation between human and coyote activity [$r=.006$, $n=10$], and a negative correlation between coyote and domestic dog activity [$r=-.612$, $n=10$, $p<.05$]. I discuss the implications of these research findings and the application of noninvasive survey methods in this, and potentially other, human-wildlife conflicts.

List of Abbreviations Used

CBHNPC	Cape Breton Highlands National Park of Canada
EDA	Exploratory Data Analysis
GIS	Geographic Information System
GPS	Global Positioning System
RAR	Relative Activity Ratio

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CHAPTER 1: Introduction

1.1 Coyotes

Coyotes (*Canis latrans*) are considered native to the grasslands and deserts of central North America (Nowak, 1978; Parker, 1995). Over the past 200 years, coyotes have gradually expanded their range across the continent (Fener et al., 2005; Foster et al., 2002; Hidalgo-Mihart et al., 2004, Laliberte & Ripple, 2004), arriving in Nova Scotia sometime in the 1970's. The first confirmed coyote was killed in Guysborough County, Nova Scotia in 1976 (Parker, 1995). By 1980, coyotes had colonized the entire province (Parker, 1995). The recent shift in coyotes' range is not without precedent; the fossil record shows that coyotes occupied a range similar to their current one in the late Pleistocene (Nowak, 1978). We can likely attribute their most recent range expansion to a combination of grey wolf (*Canis lupus*) extirpation and forest conversion (Cardoza, 1981, as cited by Foster et al., 2002; Fenner et al., 2005; Gompper, 2002). Irrespective of the forces that paved the way for coyotes, they are thriving in the forests of eastern North America (Kays, Gompper, & Ray, 2008) and are likely to be a part of this regions' ecology for the foreseeable future.

Northeastern coyotes are descended from western coyotes that travelled north of the Great Lakes on their eastward migration (Kays, Curtis, & Krichman, 2010; Nowak, 1978; Parker, 1995; Wayne & Lehman, 1992). Along the way they hybridized with both wolves and dogs. As a result, northeastern coyotes are an admixture of 3 species: approximately 84%, 8%, and 8% of their ancestry is coyote, wolf, and dog, respectively (vonHoldt et al., 2011). One apparent effect of hybridization is that northeastern coyotes are significantly larger than western coyotes (Parker, 1995; Way, 2007; Wayne & Lehman, 1992). As such, hybridization may have facilitated their eastward expansion by enabling them to take down larger prey, such as white-tailed deer (*Odocoileus virginianus*), and making them better adapted to forested landscapes (Kays, Curtis, & Kirchman, 2010). It is unclear what other implications this mixing may have for the biology, behaviour, and management of eastern coyotes. Even western coyotes, which rarely hybridize (Stronen et al., 2012), exhibit so much intraspecific variability that it is difficult to generalize about their behaviour and to identify effective management strategies for them (Bekoff, 1978).

1.2. Human-coyote Conflict

In First Nations' mythology, coyote is quite the enigmatic character; he is alternately clever and foolish, charismatic and repellent, generous and selfish, a leader and an outcast. The sheer breadth of stories about coyote in First Nations' literature and oral traditions is indicative of the important place that coyote historically held in the cultures of the southwestern and plains nations. Many western scientists and wildlife managers that study coyotes have also grown to respect and admire them. In the realm of conservation and public policy, some of the coyotes' most ardent advocates are scientists who have built their careers around the study and management of wild canids (e.g., Marc Bekoff (Project Coyote), Robert Crabtree (Yellowstone Ecological Research Center), Paul Paquette (Project Coyote)). By contrast, much of mainstream North America seems to have little or no regard for coyotes. Wile E. Coyote[1] notwithstanding, in western culture the term 'coyote' has come to connote ugliness, dishonesty, thievery, and various other illicit activities.

Following the extirpation of wolves throughout much of their historic range in North America, the animosity of ranchers and government agencies shifted from wolves to coyotes (Parker, 1995; Wilkinson, 1995). However - unlike wolves - attempts to eradicate coyotes have met with various degrees of failure (for a more detailed discussion, see Connolly, 1978). As already discussed above, coyote populations successfully colonized the continent, despite being targeted for eradication by various interest groups (e.g., ranchers, farmers, hunters) and government agencies (e.g., U.S. Fish and Wildlife Department, U.S. Department of Agriculture). Due to the evident failure of eradication campaigns and growing public opposition to them, both researchers and wildlife conflict

1 Wile E. Coyote is an animated cartoon character from a long-running series on American television. In each episode, a desperate Wile E. Coyote is humorously thwarted in his absurdly elaborate - and clever - attempts to capture his arch-nemesis and prey, the Road Runner (a cartoon bird).

managers have shifted their focus to non-lethal control and more selective lethal-control methods to manage human-coyote conflicts (e.g., Conner, Ebinger, & Knowlton, 2008; Connor, Jaeger, Weller, & McCullough, 1998; Connolly, 1978; Darrow & Shivik, 2009). That being said, from 2009-2010, Saskatchewan implemented a coyote bounty (CBC News, 2010). In 2010, Nova Scotia followed suit (Government of Nova Scotia, 2012). Both bounties have attracted widespread criticism from scientists and the international media (e.g., Fox & Genovalli, 2010). Arguably, these recent bounties demonstrate either the inexperience of both Saskatchewan's Ministry of Agriculture and Nova Scotia's Department of Natural Resources, or were geared more at addressing the emotional dimensions of human-coyote conflict than the actual root-causes. In the case of Nova Scotia, the bounty is likely aimed more at addressing the emotional dimensions of human-coyote conflict. A prior bounty in Nova Scotia from 1982-1986 failed to have any discernible impact on the coyote population and at that time it was recommended that the province employ more selective conflict mitigation measures in the future (Parker, 1995).

The first Nova Scotian coyote bounty was conceived to address early concerns about coyotes, which centred on livestock depredation, competition for wild game, and pet depredation (Parker, 1995). These early concerns mirrored the sources of human-coyote conflict throughout North America. Recently, these concerns have expanded to include the threat coyotes may pose to human safety following a fatal attack in Cape Breton Highlands National Park of Canada. In October 2009, a 19-year-old woman named Taylor Mitchell was killed while hiking alone in the Park (CBC News, 2009). This was only the second fatal coyote attack in recorded history - a 3-year-old girl was killed by coyotes in California in 1982 (Howell, 1982) - and the first fatal attack of an adult. Although coyote attacks are quite rare, concern about the potential for attacks was already on the rise prior to Taylor Mitchell's death (e.g., Timm, Bennett, Baker, & Coolahan, 2004; White & Gehrt, 2009) and has continued since (e.g., Lukasik & Alexander, 2011; Alexander & Quinn, 2011).

1.3 Cape Breton Highlands National Park of Canada

Cape Breton Highlands National Park of Canada (CBHNPC) is a 949 square kilometre park located on the northwest corner of Cape Breton Island, Nova Scotia. Although part of the Acadian forest region, the highlands contain both boreal forests and taiga. These 3 forests types provide habitat for a wide-range of animals, including several of conservation interest within the Acadian ecoregion (i.e., Canada lynx (*Lynx canadensis*), Bicknell's thrush (*Catharus bicknelli*), and American marten (*Martes americana*)). Moose (*Alces alces*) were extirpated from Cape Breton Island in the early 1900's and subsequently reintroduced to CBHNPC in the late 1940's (Bridgland, Nette, Dennis, & Quann, 2007). They have since become a management problem for the Park, but a potential boon for Park coyotes. Ever since a spruce budworm outbreak in the late 1970's, moose have prevented forest regeneration in the Cape Breton Highlands, transforming parts of the highlands from forest to grassland (Bridgland, Nette, Dennis, & Quann, 2007). Although moose do not fare so well in grassland habitats, coyotes thrive in them. Additionally, moose carcasses may represent an important food source for coyotes. Coyotes expanded into the Park relatively recently, arriving in 1980. On average, 250,000 to 300,000 people visit CBHNPC every year (Erich Muntz, personal communication, October 10, 2012) and over 100,000 visitors hike the trails within the Park (Parks Canada, unpublished data).

CBHNPC has kept records of human-coyote conflict incidents within the Park. The Park classifies human-coyote conflicts according to 3 categories of coyote behaviour: fearless, aggressive, and attack (Parks Canada, unpublished data). A fearless coyote is defined as one that fails to move away when approached by people, or one that approaches people but runs away when people try to scare it off. An aggressive coyote is a fearless coyote that will not run away when people attempt to drive it off, one that runs at people, approaches people multiple times, circles, or growls at people, but never makes physical contact. A coyote attack is defined as an instance where a coyote lunges at someone, attempts to make physical contact, or succeeds in making physical contact. Unfortunately, all records of human-coyote conflict incidents were lost when the Park switched filing systems in 2002. From 2003 to 2012, the Park documented 30 human-coyote conflict incidents. These 30 incidents comprise records of human encounters with 8 fearless coyotes, 16 aggressive coyotes, and 6 coyote attacks. By far, the most serious incident was the fatal attack that took place on October 27, 2009.

In the wake of this tragedy, CBHNPC launched a 5-year study on human-coyote conflict within the Park. The study aims to assess, understand, and respond to both the social and biophysical dimensions of this conflict. The social dimensions of the conflict include attitudes, beliefs, and behaviour toward coyotes on the part of CBHNPC visitors, local residents, and Park staff. The biophysical dimensions of the conflict include any environmental factors that may influence coyote behaviour (including human behaviour). Although the social and biophysical dimensions of human-coyote conflict are inter-related, CBHNPC has opted to research them separately. My thesis research represents a small piece of this larger study and aims to shed light on the biophysical dimensions of the conflict. In addition to my own research findings, my research will contribute to the study in other ways. The data that I have collected will be used by other researchers to assess the efficacy of hazing at causing Park coyotes to fear and avoid Park visitors.

1.4 Objectives

The primary objectives of this thesis are to 1) assess what relationships exist between coyote, human, domestic dog, and other select wildlife activity in the Park, and 2) identify times of year and sites in CBHNPC with the greatest degree of spatial overlap between human and coyote activity. My secondary objectives are to 1) ascertain whether indirect feeding opportunities correlate with increased levels of coyote activity in the Park, and 2) explore how0 moose carcasses influence spatial patterns of coyote activity in the Park.

1.5 Relevance

This research is timely. Since the fatal attack at CBHNPC in 2009, public concern about the risk coyotes may pose to human safety has been at an all-time high within the province. Moreover, this concern extends well beyond the borders of the province, as well as beyond the public arena to wildlife professionals and canid biologists. One such wildlife professional told me that after the fatal attack in CBHNPC many of his colleagues shared stories about personal encounters with aggressive coyotes which they had never shared before for fear of imparting what they, at the time, believed would have been unwarranted concerns about coyotes (Winston West, personal communication, October 2010). Before the fatal attack and having heard all these stories, he had always told people that they did not need to worry about coyotes. Now, he does not know what to tell people.

Main-stream media has done little to clarify the issue. Local media coverage of both the attack on Taylor Mitchell and subsequent human-coyote conflict incidents within the province, as well as international coverage - such as the National Geographic documentary, *Killed by Coyotes* (Spillenger, 2011) - has by-and-large sensationalized the issue. The kind of lurid journalism exemplified by this documentary serves to heighten public fear and risk perception, which may serve to exacerbate the conflict.

Our emotions influence our behaviour and our behaviour, in turn, influences the outcome of encounters with wildlife (Hudenko, 2012). For this reason, having an accurate perception of the risks associated with coyotes is extremely important. While underestimating risk may lead people to behave in ways that increase their risk of having negative encounters with wildlife (Hudenko, 2012), overestimating the risks associated with wildlife may also increase ones risk of having a negative encounter. Someone who is inordinately afraid of coyotes (maybe, in part, due to the medias' coverage of events) is perhaps more likely to panic in the unlikely event that they do encounter a coyote. Someone who is panicking is unlikely to respond appropriately, assuming they can even remember what the appropriate response is.

At present, there is very little in the way of objective information sources about coyotes within the context of this conflict available to CBHNPC, wildlife professionals, or the general public. This thesis aims to fill some small part of this knowledge gap.

1.6 Organization

The rest of this thesis is organized into three chapters and two appendices. Chapter two provides details on my field methods. Chapter three contains a publishable paper that presents the main research objectives and findings of the thesis. As it is intended as a standalone document, there is some overlap with both this introductory chapter, chapter two, and chapter four. Chapter four revisits my primary research objectives and elaborates on my two secondary research objectives, presents a more in depth analysis of the history of human-coyote conflict in CBHNPC, and ends with some thoughts on future research directions and a few concluding thoughts. Appendix A contains copies of my survey forms.

CHAPTER 2: Field Methods

2.1 Scat Survey Methods

Scat and snow tracking surveys are the two most effective noninvasive methods for detecting coyotes in northeastern North America (Gompper et al., 2006). Furthermore, the total number of coyote scats found at a given survey site correlates with coyote abundance (Kays, Gompper, & Ray, 2008). For these reasons, I elected to use scat surveys as a relative measure of coyote activity at sites across CBHNPC during the summer & fall of 2011, and the summer of 2012. During these surveys, I also documented the scats of 3 other carnivore species: bobcat (*Lynx rufus*), Canada lynx (*Lynx canadensis*), and black bear (*Ursus americanus*). Although I encountered domestic dog scats as well, I did not document them. While domestic dog activity may affect coyotes and other wildlife (George & Crooks, 2006; Lenth, Knight, & Brennan, 2008; Miller, Knight, & Miller, 2001), scat density may be a relatively inaccurate measure of domestic dog activity levels because people pick up after their dogs. For other reasons, scat surveys may be a less effective method for measuring the activity levels of Canada lynx, bobcat, and black bear than it is for coyotes. Although coyotes frequently deposit scats along human trails (Elbroch, 2003), it is unclear to what extent this is true of Canada lynx, bobcat, and black bear. Camera traps are more effective than scat surveys at detecting black bear (Gompper, 2006), and further research needs to be conducted on the comparative effectiveness of noninvasive survey techniques at detecting Canada lynx and bobcat.

2.1.1. Scat Survey Design

In addition to choosing the most effective survey methods, a variety of factors inform effective survey design. More specifically, site selection, survey number, and sampling interval are all important considerations. In the case of site selection, I chose to survey all front-country recreation sites in the western half of CBHNPC. The primary aim of my study was to gain a broad-scale overview of the relationship between coyote and human activity patterns in CBHNPC. As such, maximizing the number of survey sites[2] was critical. Ideally, I would also have surveyed front-country sites in the eastern half of CBHNPC, but a combination of logistics and limited resources confined my surveys to the western half of the Park.

Site selection and survey number are related issues. If I had chosen fewer survey sites, I could have surveyed them more often. Given the primary aim of my study, it was more important to maximize the number of survey sites than to maximize the number of surveys conducted at each site. Survey number and sampling interval are also related issues. Once I had decided to conduct more than one survey at each site, the question of how long to wait in between surveys arose. The ideal sampling interval is determined by several variables. The longer the delay between surveys, the more time new scats have to accumulate. However, the longer the delay between surveys, the more time scats also have to weather, decompose, get stepped on, run over by vehicles, or moved or eaten by wildlife. The optimal survey design would strike a balance between scat accumulation and scat persistence times (e.g., Adams, Kelly & Waits, 2003).

Scat persistence is a significant source of bias in studies that employ scat surveys. It is possible to correct for variation in scat persistence rates at different sites (Brodie, 2006); however, I had too many sites (16 total) to make such correction feasible. Two key factors that impact scat persistence time are decomposition and weather (Livingston, Gipson, Ballard, Sanchez, & Krausman, 2005). As such, scat persistence rates may vary by season (Sanchez, Krausman, Livingston, & Gibson, 2004). Seasonal variation in scat persistence was a pertinent issue in my study because my study spanned seasons. Another factor that may vary by season is diet, and the content of scats influences their decay rates

[2] Throughout this thesis I refer to the trails, campgrounds, and roads that I surveyed as survey sites, not transects. The term transect is defined as "a straight line or narrow section through an object or natural feature or across the earth's surface, along which observations are made or measurements taken" (Oxford Dictionaries, 2013). While it is not uncommon for ecologists to use trails or roads as transects (which do not necessarily run in straight lines), and transects may take the shape of squares or triangles, transects are usually the same length and chosen through some form of random sampling. By contrast, my survey sites varied in length from 0.5 km to 33 km (in accordance with the length of the trail, road, or campground loop in question) and my sites were not selected by random sampling. As such, the term transect implies a degree of correspondence and randomness that is not reflected in my surveys, thus making 'survey site' a more appropriate term within the context of this particular study.

(Godbois, Conner, Leopold, & Warren, 2005). As such, infrequent surveys may be less effective at detecting certain kinds of scats or the scats of certain species. For instance, over the course of my surveys I observed that scats containing choke cherries (*Prunus virginiana*) persisted far longer than scats containing meat or other kinds of fruit. As such, infrequent surveys may have been less likely to detect species that do not eat choke cherries (e.g., bobcats). Also, diet may impact defecation rates; when coyotes are eating fruit, they defecate more (Andelt & Andelt, 1984). Therefore, my estimates of coyote activity levels may have been exaggerated at times of year when coyotes were consuming more fruit, due to my use of scat density as an indirect indicator of coyote activity levels.

For the purpose of my research, I would have ideally surveyed each site an equal number of times and at equal intervals over the same time period. Such a survey design would have allowed the same amount of time for scats to accumulate at each site, to disappear/degrade, and provided an even sampling across seasons (thus, roughly, accounting for seasonal variation in scat persistence and defecation rates). However, my scat surveys were carried out in conjunction with other researchers who had other research goals in mind.

Other research goals included training scat detection dogs, maximizing the number of viable scats collected for corticosteroid analysis (i.e., maximizing the number of fresh scats collected), and investigating CBHNPC sites where recent human-coyote conflict incidents had taken place. The ideal survey design for these other objectives would have been more flexible and concentrated on sites where coyote scats were most often found.

Amidst these competing research objectives, I aimed to survey each site once every 4 weeks for 4 months (4 times total). On average, I succeeded. Sites were surveyed an average of 4.47 times each (SD = 2.6; range = 6). I surveyed 8 sites fewer than 4 times, and 8 sites more than 4 times. The survey interval was longer for sites that were surveyed fewer times and shorter for sites that were surveyed more often.

I decided not to clear trails of scats before the first survey, since the primary goal of my surveys was not to collect fresh scats. Another factor that entered into this decision is the fact that scats play an important role in territorial defence and maintenance, as well as communicating essential information about the fitness, social, and reproductive status of individuals (Gese, 2004). As such, removing scats is a somewhat invasive activity that might potentially have altered the activity patterns I hoped to observe without influencing. On average, I found 0.42 more scats on my first survey of a site than I did on subsequent surveys with a survey interval of 4 weeks. This difference is negligible and leads me to conclude that my decision to not clear scats from trails did not significantly bias my scat survey results.

2.1.3 Scat Identification

Carnivore scats can be accurately identified to species in certain ecological contexts (Gompper, 2006), and CBHNPC is one such context. There are a limited number of medium to large carnivores in the Park, all of whose scat can be accurately differentiated in the field based on the characteristics included on my survey form (Form A-2)**.** Research on the reliability of field identification of carnivore scats has found that eastern coyote scats can be accurately differentiated from red fox (*Vulpes vulpes*) scat based on scat diameter (Gompper, 2006), that trackers with varied degrees of tracking experience can identify coyote scats with 100% accuracy (Prugh & Ritland, 2005), and that indigenous trackers can identify the scat of all native carnivore species with 100% accuracy (Zuercher, Gipson, & Stewart, 2003).

At present, there are only 6 species of medium to large carnivores in western CBHNPC: coyote, bobcat, Canada lynx, black bear, northern raccoon (*Procyon lotor*), and northern river otter (*Lontra canadensis*). While red fox are found in the eastern lowlands of the Park, I did not detect them in the highlands or western lowlands during either my scat, snow tracking, or remote camera surveys. According to CBHNPC staff and Cheticamp residents, red fox are not found in the western half of CBHNPC and my survey results confirm this. While northern river otters are present, their scats are easy to differentiate from the other carnivore species based on content and morphology because they are piscivores. Also, they are unlikely to deposit scats on trails or along roads; I did not encounter any otter scats during my surveys.

Scats of the remaining 5 species can be differentiated based on scat diameter, content, and ecological context. Both northern raccoons and bobcats are relatively recent arrivals on Cape Breton Island. According to local ecological knowledge raccoons are only rarely found in the lowland areas of CBHNPC, and never in the highlands. I did find one putative raccoon scat on an old bridge along an abandoned trail in the highlands, however I could not identify this scat with a high degree of confidence. Raccoons tend to defecate on top of things (e.g., fallen logs, bridges) or to form latrines at the bases of trees (Elbroch, 2003), so contextual clues make it unlikely that raccoon scats would be confused with other medium-sized carnivore scats in CBHNPC.

Bobcats arrived on Cape Breton Island in the 1950's (Parker, 1995). As of 1983, bobcats were found in CBHNPC, but not in the highland portions of the Park (Parker, Maxwell, Morton, & Smith, 1983). Bobcats may not yet have dispersed into the highlands at that point in time. At present, there is no reason to believe that bobcats are not present in the Cape Breton Highlands. However, I did not detect any there during my winter snow tracking and remote camera surveys. The highest elevation at which I detected bobcats was near Paquette Lake, at approximately 280 m above sea level. In the absence of more reliable data on the current range of bobcats in CBHNPC, I identified all the cat scats that I found in the highlands as Canada lynx, and all the cat scats that I encountered in the lowlands as bobcat scats.

Felids are true carnivores. As such, any scats that contained fruit could not have been bobcat or Canada lynx scats. Throughout most of my survey period (July-October), ripe fruit was available and heavily used by coyotes and black bears. Coyote and black bear scats can easily be differentiated by size, although there may be some overlap between large coyote scats and the scat of black bear cubs (Elbroch, 2003). During my survey period (July-October), black bear cubs were likely big enough that their scats would be larger than coyote scats.

In cases where scats had no fruit in them, I relied on scat size, morphology, scent, and contextual clues for species identification. It was not always possible to identify these scats with 100 % confidence, however in some cases it was possible. While there is some overlap in the diameter of bobcat, Canada lynx, and coyote scats, large coyote scats have a larger diameter than large bobcat or Canada lynx scats (Elbroch, 2003). I used 2.5 cm as a dividing line between bobcat or Canada lynx scats and coyote scats. Also, felid and canid scats have distinctly different scents. Although bobcat and coyote scats are shaped differently, scat morphology can vary a great deal depending on the diet and health of the animal in question. As such, it is more difficult to accurately incorporate morphology into a reliable scat identification. To do so, I relied heavily on my own tracking experience.

2.1.2 Scat Survey Protocol

At the beginning of each scat survey, I filled out a session form (Form A-1). On this session form, I recorded the date, site name, the time I began the survey, the location I began the survey from, and the names of any other trackers who accompanied me. Over the course of the survey, I looked for scats on the trail or road (depending on the survey site), and anywhere within either 2 m of the trail, or on the shoulder of the road. When I found a scat, I first assessed whether the scat was intact enough for me to accurately identify to species. I did not identify to species any scat that was either too degraded or too loose for me to obtain an accurate measure of its diameter.

In some cases, I could not get an accurate diameter measurement but could tell by the content of the scat that it was made by a carnivore that was not a domestic dog (e.g., it contained food items which domestic dogs would either be unlikely to consume, or unlikely to consume in such quantities). In these cases, I gave the scat a unique identifier and recorded that number, along with the GPS coordinates of the scat, the error, and the content of the scat, on the back of my session form.[3] These unidentifiable carnivore scats were labeled ‘carnivore’ in the species field of my spreadsheet.

When I found a scat that was intact enough for me to obtain an accurate diameter measurement, I filled out a scat form (Form A-2). I chose which characteristics to observe and document in the descriptive and contextual sections of my form based on a combination of personal tracking experience and the discussion of scat interpretation in Mark Elbroch's field guide, *Mammal Tracks & Sign: A Guide to North American Species*

[3] Documenting these unidentifiable carnivore scats allowed me to account, to some extent, for possible variation in scat persistence from site to site.

(2003). Species identifications were based on a combination of scat size, content, morphology, scent, and ecological context.

In the interpretive section of my form, I assigned each scat a confidence rating and age score. Confidence ratings ranged from 1 through 3, with 1 representing 100% confidence in identification, 2 signifying slightly less than 100% confidence, 3 indicating some uncertainty, but more than 50% confidence in identification. Any carnivore scat I could not identify to species with more than 50% confidence (but which – based on content – was unlikely to be a domestic dog scat). All scats encountered on surveys were either collected, pulled apart, or kicked to the side of the trail in order to avoid data duplication on subsequent surveys.

I assigned each scat an age score of 1 through 3. Age 1 scats were judged to be hours old; Age 2 scats were days old; Age 3 scats were a week or more old. I based my age estimates on a combination of scent, moisture content, and the state of any vegetation underneath the scat. Moist, smelly scats were judged to be fresher than dry, scentless scats. Both weather conditions and the content of the scats influenced my weighting of these characteristics (e.g., recent rain could add moisture to scats, scats full of berries tend to take longer to dry out than scats full of hair etc.). Also, after about a week any vegetation under a scat turns from green to yellow or brown (Elbroch, 2003). All age 1 scats were collected for corticosteroid analysis. However, I did not collect the entire scat for reasons outlined in the last paragraph of section 2.1.1. All scats encountered on surveys were either collected (in part), pulled apart, or kicked to the side of the trail in order to avoid data duplication on subsequent surveys.

Finally, I took two photographs of each scat. The first photograph was a close-up of the scat with a horizontal and vertical scale in the picture. I used a tracking ruler from Keeping Track, Inc. for this purpose. The second picture was a landscape photo, showing the ecological context of the scat. Later, if there were any questions regarding the accuracy of my field identification, I could refer back to these photos. If at the time, I had any qualms about my field identification of the scat, I would enter my questions and equivocations into the notes section of the scat form (Form A-2) to consider later. At the end of each survey, I recorded the time, end location, and total distance surveyed. I also noted any potential food sources I encountered during the survey (e.g., ripe *Amelanchier spp.* berries etc.) and weather trends.

2.2 Snow Tracking Survey Methods

Ideally, a survey would employ only one method in order to avoid the challenges of evaluating and integrating data from different sources (Campbell et al., 2008). However, no one survey technique works equally well across seasons in CBHNPC. The Cape Breton Highlands receives an average of 400 cm of snowfall each year (Nova Scotia Natural History Museum, 2013), and it snows almost every night. There is no snow in the summer and fall, and during the winter scats are quickly buried in snow. As such, scat survey are a less effective method for detecting coyotes in CBHNPC in the winter than they are in the summer and fall.[4] Therefore, I opted to use snow tracking surveys in the winter.

2.2.1 Snow Tracking Survey Design

Effective snow tracking and scat survey design are both informed by similar considerations. As mentioned in section 2.1.1, these considerations include site selection, survey number, and sampling interval. I had more resources for my winter snow tracking surveys. As a result, I was able to survey sites across CBHNPC (rather than being confined to the western side of the Park, as I had been in the summer and fall). Unfortunately, CBHNPC had no data on winter trail use to guide me in my site selection. In consultation with Park staff, I selected a subset of 10 sites (8 trails, 2 campgrounds) from the 30 front-country recreational sites in the CBHNPC (26 trails, 4 campgrounds). Based on the anecdotal observations of Park staff, 9 of these 10 sites would receive a range of regular use by Park visitors. Skyline Trail was not among these 9 trails, but I chose to include it in the survey because of the history of human-coyote conflict at this site.

[4] During my winter surveys, I found only 26 scats. Whereas, during my summer and fall surveys I found 622 scats, despite comparable survey effort (319 km of surveys in the winter vs. 276 km of surveys in the summer and fall).

I conducted 5 snow tracking surveys at each site over the course of the winter. Other researchers have recommended a minimum of 3 snow tracking surveys at each survey site (e.g., Halfpenny, Thompson, Morse, Holden, & Rezendes, 1995). However, these recommendations are based on different research aims than my own (namely, the detection of extremely rare and elusive species to ascertain population distributions and trends). For the purpose of my research, I wished to gain a detailed picture of wildlife activity patterns and 5 surveys was the maximum number of surveys that I could reasonably accomplish in the allotted time. In the case of snow tracking surveys, survey number and survey interval are not as closely related as they are in scat surveys. Although track accumulation time needs to be controlled for, it is a matter of time since last snow as opposed to time since last survey.

Ideally, snow tracking surveys should be conducted three days after the last survey in order to allow time for tracks to accumulate (Bayne, Moses, & Boutin, 2005). However, in the Cape Breton Highlands it snows almost every night. As such, waiting three days was not practicable. Instead, I made tracks in the snow every night at approximately 10 pm, and then went out the next morning to see how much snow had fallen in my tracks. If there was 1 cm of snow or less in my tracks and it was not actively snowing (i.e., light flurries were fine), then I would conduct a survey.

The snow tracking situation in CBHNPC was further complicated by the fact that temperatures routinely rose above freezing during the day time and so it not only snowed, but rained, and on warm, sunny days tracks could be erased by snow-melt. On the rare occasions when more than one or two days passed without any new rain or snowfall, daytime temperatures were usually above freezing, causing tracks to melt. In planning my surveys, I kept track of the number of days since the last snow/rain fall, and also made note of whether daytime temperatures had risen above freezing the day before (Table 1).

To the best of my ability, I sought to balance track accumulation times at my ten survey sites. The median number of track accumulation days was two. The median decreased to one day when snow-melt was factored in. All sites had a median track accumulation time of either 1 or 2 days. Weather can vary significantly across the CBHNPC, both between the lowlands and highlands and the eastern and western sides of the Cape Breton Island. As a result, on two different surveys I was unable to determine the last time it had snowed at the site.

Table 1. Snow tracking survey effort

Site	Survey Dates (Days Since Last Precipitation)					MEDIAN	AVE.
Cheticamp Campground	J7 (1)	J12 (1)	F10 (2)	M2 (2)	M30 (2)	1, 1, **2**, 2, 2	1.4
Salmon Pools	J5 (1)	J12 (1)	F29 (1)	M7 (?)	M29 (1)	1, **1, 1**, 1	1
Skyline	J10 (1)	F9 (1)	M1 (1)	M8 (?)	M18 (3*)	1, **1, 1**, 3*	1.5
Benjie's Lake	J10 (1)	F10 (2)	M1 (1)	M17 (2)	M31 (3)	1, 1, **2**, 2, 3	1.8
Paquette Lake	J23 (2)	F6 (1)	F17 (4*)	F22 (3)	M10 (1)	1, 1, **2**, 3, 4*	2.2
Black Brook (G)	J30 (1)	F3 (1-2)	F20 (1)	M13 (2*)	A2 (7*)	1, 1, **1-2**, 2*, 7*	2.5
Mary Ann Falls (G)	J25 (1)	F5 (0)	F16 (3*)	M13 (2*)	A2 (2*)	0, 1, **2***, 2*, 3*	1.6
Warren Lake Trail (G)	J17 (1)	F1 (1)	F14 (1)	F23 (1)	M20 (4*)	1, 1, **1**, 1, 4*	1.6
Broad Cove CG (G)	J23 (2)	F15 (2)	F22 (3)	M6 (1)	M20 (4*)	1, 2, **2**, 3, 4*	2.4
Clyburn Valley	J22 (1)	J31 (2)	F13 (1)	F21 (2)	M19 (3*)	1, 1, **2**, 2, 3*	1.8
J = January; F = February; M = March; A = April; *Was above freezing the day before the survey							

2.2.2 Track Identification

For the winter snow tracking surveys, I had 7 target species: coyote, red fox, bobcat, Canada lynx, snowshoe hare (*Lepus americanus*), white-tailed deer, and moose. In addition to these 7 target species, I observed the track and sign of northern river otters, northern raccoons, and numerous small mammals, including ermine (*Mustela erminea*), deer mice (*Peromyscus maniculatus*), squirrels, voles, and shrews. I did not, however, encounter any Canada lynx tracks.

Tracks were identified based on a combination of shape, size, track detail, gait pattern, and ecological context. In some cases, all the information I needed to identify a set of tracks to species was in the gait pattern. For instance, both moose and snowshoe hare could be readily identified by their gait patterns alone. In other cases, I had to trail coyotes, red fox, and bobcats for some distance before I was able to make a definitive identification, either by finding more detailed tracks in microhabitats, observing other sign (e.g., fox urine), or observing trail patterns (e.g., bobcats walking along downed trees in the forest). On a few occasions, I had to rely on gait measurements to distinguish fox from coyote trails. In these instances, I relied on the gait measurements in Elbroch (2003), and found that I was able to make a definitive identification based on a trail width that was either too narrow to be a coyote trail or too wide to be a fox trail.

2.2.3 Snow Tracking Survey Protocol

I used a tape recorder to document my snow tracking survey observations. The information I documented is included in Appendix A (Form A-3). At the start of each survey, I recorded the site name, date, start time for the survey, weather conditions, snow depth (in centimetres), and snow condition. I used a piece of steel rebar to measure snow depth. I would plunge the rebar into the snow pack until I felt it hit the ground, then use my finger to mark where the rebar was level with the surface before pulling the metal rod out of the snow pack. I would then measure the length between my finger and the end of the bar. Snow condition was classified according to 6 categories: powder, drifting, freeze-thaw crust, ice-crust, wind-packed snow, and slush. These categories were based on local snow conditions that I had commonly observed. I either hiked or snowshoed each survey site, depending on snow depth and the hardness of the snow pack.

During the survey, I looked for tracks on and adjacent to the trail or road (anywhere between the edge of the trail/road and the forests' edge). I gave each set of tracks I encountered a unique identification number, recorded this number, the GPS coordinates, and error, noted the species, and assigned ratings for confidence, age, and snow quality.

Track identification is inherently less ambiguous than scat identification, particularly with clear tracks in snow. For this reason, I had only 2 confidence ratings for my snow tracking surveys. I assigned a confidence rating of 1 to tracks that I could identify to species with 100 % confidence, and a confidence rating of 2 to tracks that I could not identify to species. Tracks were sometimes unidentifiable because they had too much snow in them, or were too deformed by snow melt, for me to observe any track detail or to obtain reliable trail measurements.[5]

I assigned each track an age score of 1, 2, or 3. Age scores were based on Louis Liebenberg's discussion of aging tracks in *The Art of Tracking: The Origin of Science* (2001). Age 1 tracks were part of a fresh trail (i.e., I either saw the animal that made the tracks, or probably could have seen the animal that had made the tracks by following its trail); Age 2 tracks were part of an old trail (i.e., if I had followed the trail, I might have found the animal that made the tracks, but it would have taken many hours or even days); Age 3 tracks were part of a dead trail (i.e., no matter how long I followed the trail, I would never have caught up with the animal at the end of the trail).

My snow quality ratings were based on the snow surface quality ratings summary in Halfpenny et al. (1995). For carnivore and snowshoe hare tracks, I was able to use Halfpenny et al.'s (1995) snow quality ratings without making any modifications. However, for deer and moose I had to modify these snow quality ratings because every track registered, regardless of the snow surface quality. Instead of using snow quality ratings of 0 through 4 (as summarized in Halfpenny et al., 1995), I only used ratings of 1 through 4 for deer and moose, and did not use the extent to which prints registered as a basis for my assessment. Also, despite the fact that moose tracks could always be identified by their gait pattern, in my assessment I took into account how much detail was present in the tracks.

I found that wildlife frequently travelled on the trails and roads I surveyed (as opposed to bisecting them) and that wildlife trails were frequently obscured by human trails. As a result, it was sometimes impossible to ascertain whether a wildlife trail found merging with the recreational trail was the same individual (or individuals) found diverging from the recreational trail at another point. To address this uncertainty, I documented wildlife trails wherever they joined or left the trail/road, resulting in an

[5] In the absence of track detail, my inability to obtain accurate trail measurements posed a challenge to species identification with certain species and gait patterns. When snow melts, tracks have a tendency to both lose their overall shape (e.g., round, oval) and to expand in size. In some gait patterns, bobcat, Canada lynx, coyote, and red fox have trail measurements that either overlap, or are similar enough that melted tracks could lead to some uncertainty.

amplification of wildlife activity levels at sites where wildlife travelled on the trail/road. Wildlife trails that either bisected or dipped out of the woods alongside the trail/road were only documented once. At the end of each survey, I recorded the time and distance surveyed, and weather trends over the course of the survey. Before the next survey, I transcribed my field observations.

CHAPTER 3: Human-coyote Conflict in Cape Breton Highlands National Park of Canada

This paper will be submitted to the journal *Biological Conservation* for publication. The authors of the paper will be - in order of appearance - Kate Porter, Shantel Sparkes, and Simon Gadbois. I researched and wrote the paper; Shantel Sparkes assisted with data collection, as did Simon Gadbois, who in his role as my supervisor also provided indispensable guidance that improved the quality of the research, analysis, and resulting manuscript.

Abstract

We demonstrate how noninvasive survey techniques may be used to elucidate the biophysical dimensions of human-wildlife conflict and to inform effective management of conflicts. From 2011 to 2012, we employed a combination of scat, snow tracking, and remote camera surveys to research human-coyote conflict in Cape Breton Highlands National Park of Canada (CBHNPC). These techniques enabled us to assess spatial relationships between coyote and human activity within the Park, while minimizing our potential impact on these relationships, and to identify times of year and locations with the greatest degree of co-occurrence. We surveyed a total of 22 recreational sites across CBHNPC. In the summer and fall, we discovered a large, negative correlation between spatial patterns of human and coyote activity. In the winter, we found a large, negative correlation between coyote and domestic dog activity, and no correlations between coyote and other human activities. An exploratory analysis of our spatial data revealed 8 sites with particularly high levels of both coyote and human activity, and 2 high priority sites for future monitoring. Our research findings correspond with the history of human-coyote conflict within CBHNPC and suggest potential hot spots for future conflict. We discuss how these research findings might be applied to manage human-coyote conflict in CBHNPC and how our methodological approach might be employed to study other human-wildlife conflicts.

3.1 Introduction

Human-wildlife conflicts pose a significant threat to the welfare and persistence of wildlife. As such, wildlife conservationists need to identify, develop, and implement effective methods to mitigate conflicts. The need for more effective methods, or more efficient use of existing methods, becomes even more pressing in conflict situations where wildlife may also pose a threat to human safety.

Although a variety of lethal and non-lethal control methods exist to address the biophysical dimensions of conflicts, we can be hampered in our attempts to select and effectively apply control methods by a lack of objective insight into the biophysical extent and nature of specific conflicts. Deeper insight could help wildlife managers identify sites with the greatest potential for future human-wildlife conflict, and thus make more precise (and perhaps effective) use of invasive and lethal control methods to manage conflicts.

Research on the biophysical dimensions of human-wildlife conflict faces the additional challenge of identifying appropriate research methods. Invasive research methods can have wide-ranging impacts on the welfare and behaviour of wildlife (e.g., Alibhai & Jewell, 2001; Alibhai, Jewell, & Towindo, 2001; Cattet et al., 2006; Cattet, Boulanger, Stenhouse, Powell, & Reynolds-Hogland, 2008; Dyck et al., 2007; Moorhouse & Macdonald, 2005; Tuyttens, Macdonald, & Roddam, 2002). One study found that repeated captures significantly impacted the ranging behaviour of black bears and grizzly bears (Cattet et al., 2008). This particular study hints at the potential impacts that invasive survey methods may have on behaviour relevant to human-wildlife conflicts. If invasive survey techniques influence wildlife movement patterns, they may indirectly influence the probability of people encountering wildlife. By contrast, one of the strengths of noninvasive methods is that they do not have much impact on wildlife movement patterns (Heinemeyer, Ulzio, & Harrison, 2008). Furthermore, researchers using noninvasive methods do not directly interact with the wildlife they study, thus further decreasing the potential for researchers to impact the behaviour they aim to study. For these reasons, we elected to use noninvasive survey techniques in our research on the biophysical dimensions of human-coyote conflict in CBHNPC.

Human-coyote conflicts are wide-spread and long-standing. Most conflicts centre around predation on livestock, pets, and competition for wild-prey (Parker, 1995), however conflicts that stem from human safety concerns exist (Alexander & Quinn, 2011; Carbyn, 1989; Lukasik & Alexander, 2011; Timm, Baker, Bennett, & Coolahan, 2004; White & Gehrt, 2008), and have recently intensified, following a fatal attack in CBHNPC on October 27, 2009. A 19-year old woman was attacked by 3 coyotes while hiking alone in the Park and died the next day. Seven coyotes were shot near where she was attacked, and the following year Nova Scotia initiated a coyote bounty, which remains ongoing. Both before and since this fatal attack, visitors to CBHNPC have been attacked by coyotes (Parks Canada, unpublished data).

Our research aims to assess the degree of spatial overlap between human and coyote activity in CBHNPC and to identify areas within the Park with the greatest degree of overlap between human and coyote activity. This information will help identify sites in CBHNPC with human-coyote conflict potential, and to prioritize sites for monitoring and conflict mitigation efforts (e.g., hazing coyotes). We anticipate a negative correlation between coyote and human activity, as well as coyote and domestic dog activity. We expect to find a positive correlation between coyote activity and certain kinds of litter (i.e., human-associated food items, food containers, and food wrappers). Spatial patterns of coyote activity may also be related to the activity patterns of other wildlife in CBHNPC. We expect to find a negative correlation between coyote and red fox activity, but a positive correlation between coyote and snowshoe hare activity, as well as between coyote and white-tailed deer activity. We anticipate no correlation between coyote activity and the activity of bobcat, Canada lynx, black bear, or moose.

3.1.1 Study Area

CBHNPC is a 949 km^2 protected area located in northwestern Nova Scotia (Figure 1). Although Nova Scotia is part of the Acadian Forest Region, CBHNPC also contains both Taiga and Boreal Forest. These 3 forest types provide habitat for a wide range of plants and animals, including many species of conservation interest. The Acadian Forest covers most of the lowland areas of the Park; Taiga and Boreal Forests cover the highlands.

Coyotes are a relatively recent addition to the Park; the first coyote was observed in the western lowlands in 1980. Coyotes have since become a ubiquitous part of CBHNPC's fauna.

Four communities abut the Park boundary and 250,000-300,000 people visit CBHNPC each year. There are 145 kilometres of trails, 81 km of highway, 8 campgrounds, and 12 picnic areas in the Park (Figure 2). CBHNPC is open year-round, however the majority of people visit in the summer and early fall. Much of the backcountry is only accessible in the winter, and 13.5 km of groomed cross-country ski trails are maintained in the front-country.

3.2 Methods

Spatial patterns in coyote and other wildlife activity (i.e., bobcat, Canada lynx, black bear, red fox, snowshoe hare, white-tailed deer, and moose) were gauged using a combination of scat and snow tracking surveys. These two survey techniques are the most effective noninvasive methods for detecting coyotes in northeastern North America (Gompper et al., 2006), and maximized our ability to assess coyote activity across seasons. Although snow tracking surveys are a reliable method for detecting most species that are active in the winter, trail-based scat surveys may be less effective at detecting species other than coyotes and red fox (Gompper et al., 2006). As a result, our winter snow tracking surveys may provide a more accurate measure of wildlife co-occurrence than our summer and fall scat surveys.

We conducted 276 km of scat surveys from August-October, 2011, and in July, 2012. Our scat survey sites included 14 trails, the Cheticamp Campground, and a 33 km stretch of the Cabot Trail (Figure 3). These survey sites comprised all front-country recreation sites within the western half of CBHNPC. We were unable to include any recreational sites within the eastern half of the Park during our summer and fall surveys due to limited resources (e.g., housing, transportation). Sites were surveyed an average of 4.47 times each (SD = 2.6; range = 6). We surveyed trails and the campground on foot, and the Cabot Trail from a vehicle moving at 20 km/hr. We documented the scats of all medium to large carnivore species that we encountered (i.e., coyotes, bobcats, Canada

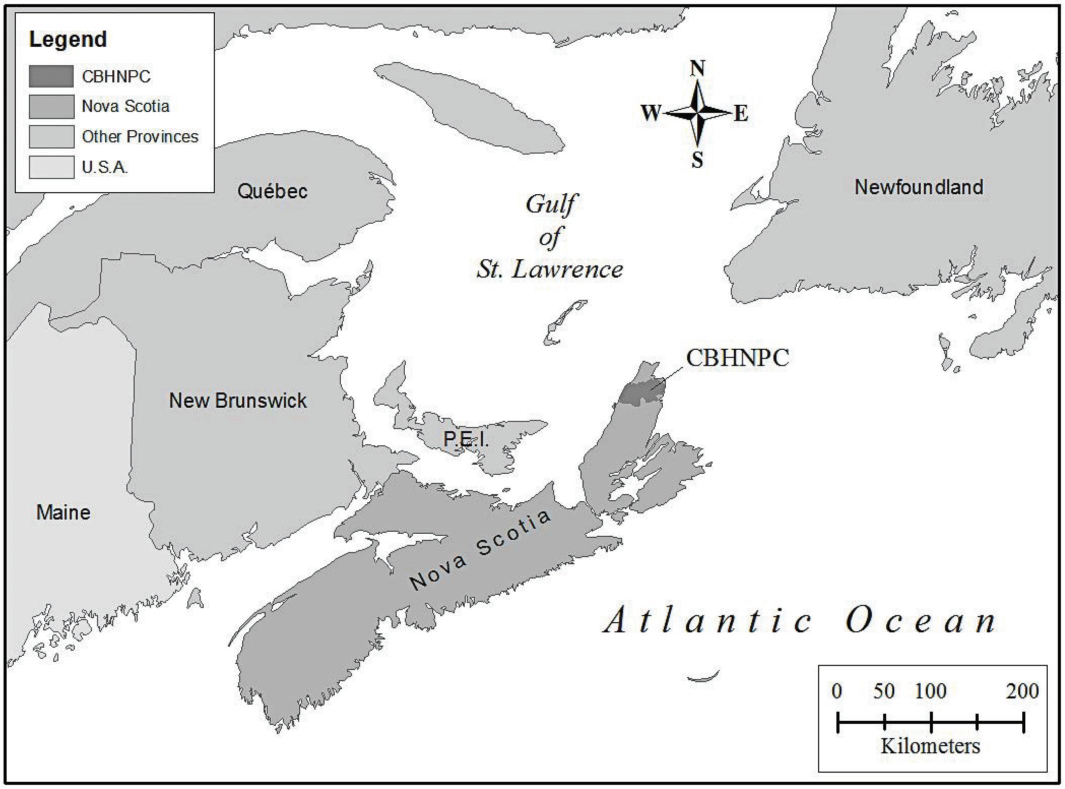


Figure 1. Location of Cape Breton Highlands National Park of Canada

lynx, and black bears). Scats were identified to species based on a combination of scat size, content, morphology, scent, and ecological context. We also documented all carnivore scats that we could not identify to species, but were nonetheless confident were not made by domestic dogs because the scats contained food items which domestic dogs would either be unlikely to consume, or unlikely to consume in such quantities. We assigned confidence ratings of either 1, 2, 3, or 4 to each carnivore scat we encountered. A confidence rating of 1 signified 100% confidence in species identification, 2 denoted slightly less than 100% confidence, 3 indicated greater uncertainty, however still more than 50% confidence in identification, and we assigned a confidence rating of 4 to any carnivore scats we could not identify to species with more than 50% confidence.

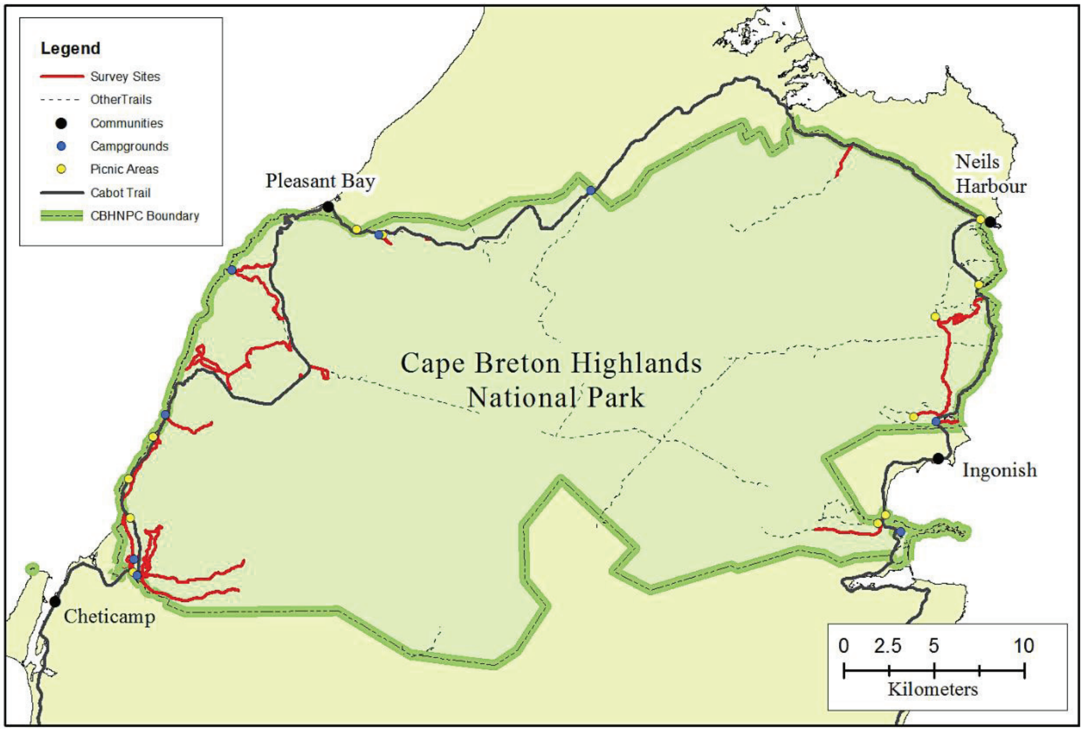


Figure 2. Cape Breton Highlands National Park of Canada

We conducted 319 km of snow tracking surveys from January-April, 2012. Our snow tracking survey sites included 5 trails, 2 campgrounds, and 3 roads[6] (Figure 4). These 10 survey sites were selected in consultation with CBHNPC staff. We selected sites based on a combination of popularity among recreationists and history of human-coyote conflict in CBHNPC. Each trail was surveyed 5 times over the course of the winter on snowshoes. We documented any tracks we encountered belonging to coyotes, potential competitors (i.e., bobcat, Canada lynx, and red fox), 2 potential prey species (i.e., snowshoe hare and white-tailed deer), and moose. Tracks were identified to species based on a combination of shape, size, track detail, gait patterns, and ecological context. Track identification is inherently less ambiguous than scat identification, and our confidence ratings reflected this reality. We employed only 2 confidence ratings for tracks: Tracks that we could identify to species were assigned a confidence rating of 1, and tracks that

[6] These 3 roads are unploughed, and 2 of them are groomed as ski trails by CBHNPC during the winter.

were too degraded or obscured by snow to identify to species were assigned a confidence rating of 2.

In the summer and fall, data on human activity at our scat survey sites was collected with remote counters. Remote counter data was obtained from CBHNPC. From 2005-2010, CBHNPC used remote counters to determine the total number of hikers/bikers who use each Park trail from June through October (Parks Canada, unpublished data). In the winter, we used remote cameras to collect data on human and domestic dog activity patterns at our snow tracking survey sites from January-April, 2012. We employed 4 RECONYX™ SM750 HyperFire™ remote cameras (RECONYX, Inc., Holmen, Wisconsin, 2011, www.reconyx.com) and 6 Bushnell® Bone Collector™ Trophy Cam remote cameras (Bushnell Corporation, Overland Park, Kansas, 2011, www.bushnell.com). All remote cameras were sited within 1 km of the trailhead, fitted with lockboxes, and concealed to minimize risk of theft and vandalism. Camera settings (i.e., capture number, picture interval, trigger delay, and sensor level) varied according to the strengths and weaknesses of the camera model in use and the unique characteristics of the site (e.g., wind-exposure, field of view). In order to minimize data loss due to camera maintenance issues and camera malfunction, cameras were checked at least once a month throughout the survey period. Remote cameras collected an average of 68 days' worth of data (SD = 18, range: 53 days).

Although we obtained pictures of coyotes and other wildlife with our remote cameras during the winter, we elected not to incorporate this data into our analysis. Remote cameras are relatively ineffective at detecting coyotes (Gompper et al., 2006; Larrucea & Brussard, 2007). As such, snow tracking represents a more reliable source of information on spatial patterns of coyote activity. Based on our remote camera and snow tracking survey results, snow tracking is also more effective than remote cameras at detecting bobcat, snowshoe hare, and deer in CBHNPC, and equally effective at detecting red fox and moose. Furthermore, remote cameras only cover the area within their field of view. We wanted to assess spatial patterns of coyote and other wildlife activity along the entire length of our surveys, not just a single location at each of our survey sites.

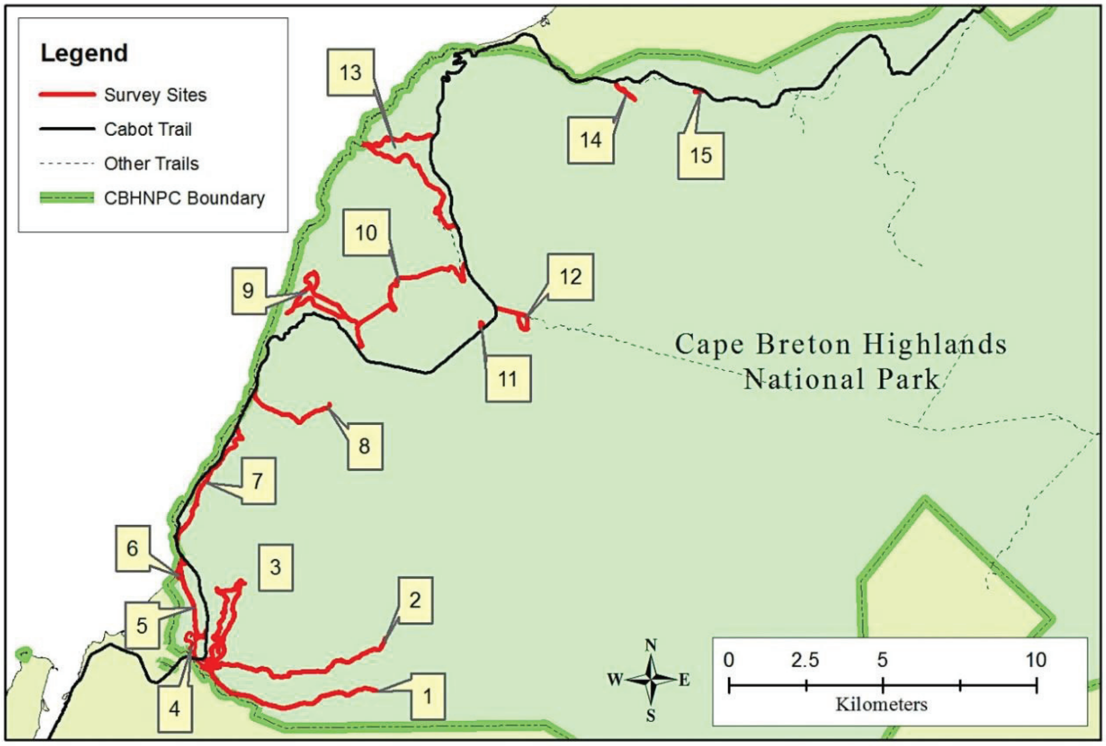


Figure 3. Summer and fall survey sites in CBHNPC

1. Salmon Pools Trail
2. Lake Trail
3. Acadian Trail
4. Cheticamp Campground
5. Le Chemin du Buttereau Trail
6. Le Buttereau Trail
7. Cap Rouge Trail
8. Corney Brook Trail
9. Skyline Trail
10. Old Cabot Trail
11. Bog Trail
12. Benjie's Lake Trail
13. Fishing Cove Trail
14. McIntosh Brook Trail
15. Lone Shieling Trail

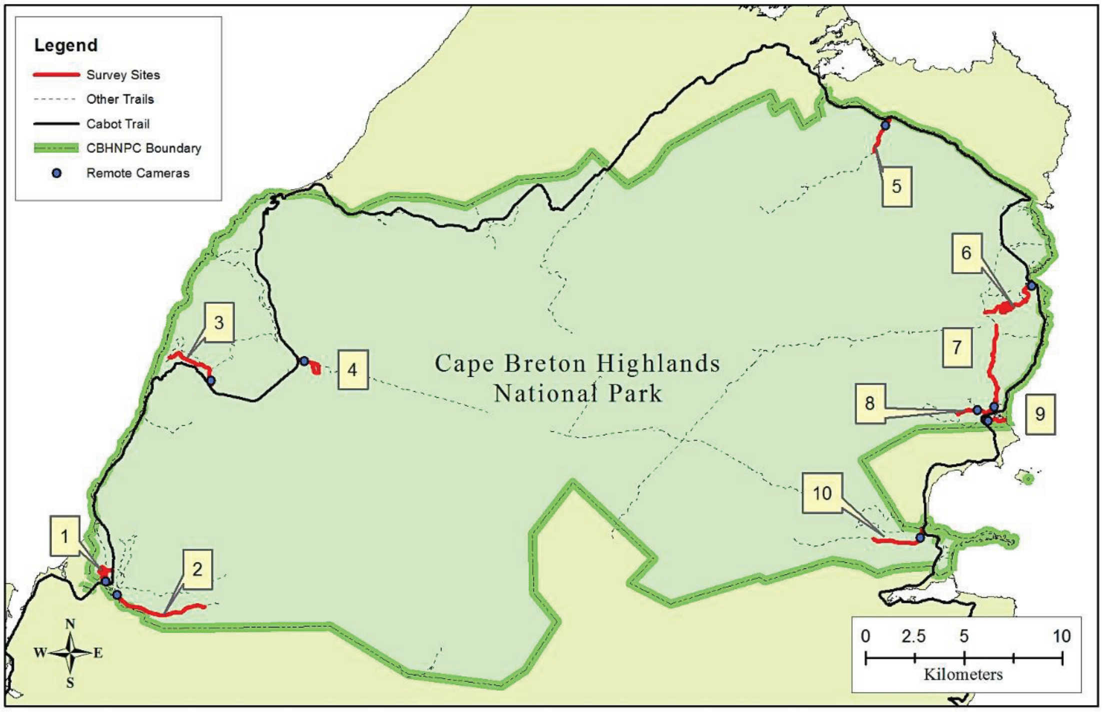


Figure 4. Winter snow tracking survey sites in CBHNPC

1. Cheticamp Campground
2. Salmon Pools Trail
3. Skyline Trail
4. Benjie's Lake Trail
5. Paquette Lake Road
6. Black Brook Trail
7. MaryAnn Falls Road
8. Warren Lake Road
9. Broad Cove Campground
10. Clyburn Valley Trails

3.3 Data Analysis

For each site and season, we calculated a relative activity ratio (RAR) for human, domestic dog, coyote, and other assorted wildlife activity. Human and domestic dog RARs were calculated according to the methods outlined in George & Crooks (2006). For the summer and fall, we calculated a RAR for humans at each site by dividing the unique number of hikers/bikers detected by remote counters on each trail by the number of days each remote counter was operational (Equation 1). For the winter, we added up the total number of people, skiers, snowshoers, hikers, or domestic dogs detected by our remote cameras at each site, and likewise, divided those numbers by the total number of days each remote camera was operational (Equation 1). This enabled us to adjust for days lost due to camera maintenance issues and camera malfunction.

We adapted George and Crooks (2006) method for calculating RARs, used with remote camera data, to analyze our scat and snow tracking survey data. We only used scats with confidence ratings of either 1 or 4, and tracks with a confidence rating of 1, in our calculations. For the summer and fall scat surveys, we calculated a RAR for each species at each site by pooling the total number of scats found at each site by species, and then dividing that number by the length of the survey at that site (Equation 2). RARs for our winter snow tracking surveys were calculated using a similar method, only using the total number of tracks instead of scats (Equation 2). This allowed us to adjust for different survey lengths. Additionally, we calculated a relative density of food waste (i.e., human food items, food containers, and wrappers) for each site, by dividing the total number of items found at each survey site by the total length of the survey (Equation 3).

Equation 1. Human and domestic dog RARs

$$\text{RAR} = \frac{\text{(Number of recreationists or domestic dogs detected at survey site)}}{\text{(Number of days the remote counter or camera was operational at that survey site)}}$$

Equation 2. Wildlife RARs

$$\text{RAR} = \frac{\text{(Number of species' tracks or scats detected at survey site)}}{\text{(Length (in kilometres) of survey at that site)}}$$

Equation 3. Food Waste RARs

$$\text{RAR} = \frac{\text{(Number of anthropogenic food items, containers, and wrappers found at survey site)}}{\text{(Length (in kilometres) of survey at that site)}}$$

For the summer and fall scat surveys, the relationships between coyote, bobcat, Canada lynx, black bear, and other carnivore RARs, human RARs, and food waste RARs, were investigated using Spearman's rank order correlation (Table 2) (Sokal & Rohlf, 1973). We performed one-tailed Spearman's rank order correlation tests on the relationships between coyote RARs and human RARs, and food waste, as well as between human and carnivore RARs (grey cells in Table 2). As mentioned in the introduction, we expected an inverse correlation between coyote and human activity levels. This expectation was based on previous research (i.e., George & Crooks, 2006). We suspected that food-conditioning might play a role in human-coyote conflict in CBHNPC, and as such hypothesized a positive correlation between coyote RARs and food waste. We also expected a positive correlation between human activity and food waste, and between human and carnivore RARs, because higher levels of human activity may reduce our ability to identify scats to species as a direct result of people stepping on scats or driving over them. We performed 2-tailed Spearman's rank order correlation tests on the relationships between the remaining variables, as we either anticipated no relationship, or were unsure whether a relationship might exist (white cells in Table 2).

For the winter snow tracking and remote camera surveys, the relationships between coyote, red fox, bobcat, snowshoe hare, white-tailed deer, moose, domestic dog, and human RARs were also investigated using Spearman's rank order correlation (Table 3) (Sokal & Rohlf, 1973). We performed 1-tailed Spearman's rank order tests on the relationships between a) human, domestic dog, and coyote RARs, b) coyote, and fox, hare, and deer RARs, c) fox and hare RARs, d) bobcat and hare RARs, and, e) deer and moose RARs (grey cells in Table 3). We anticipated an inverse correlation between human and coyote RARs for the same reasons in the preceding paragraph. Furthermore, we expected a positive correlation between human and dog RARs, as there are no feral dogs in CBHNPC. We anticipated an inverse correlation between coyote and domestic dog RARs as a by-product of coyotes avoiding sites with higher levels of human activity. Additionally, we expected positive correlations between various types of human activities because we anticipated human activity levels would vary more by site than by type of activity (e.g., the most popular recreational sites would be popular amongst all types of recreationists). Based on the literature, we anticipated inverse correlations between coyote and fox RARs, as well as deer and moose RARs. Also based on the literature, we expected positive correlations between coyote and hare RARs, coyote and deer RARs, fox and hare RARs, and bobcat and hare RARs. We performed 2-tailed Spearman's rank order tests on the relationships between the remaining variables, as we either anticipated no relationship, or were unsure whether a relationship might exist (white cells in Table 3).

3.4 Results

3.4.1 Summer and Fall

Table 2. Spearman's rank order correlations between wildlife and human RARs in the summer and fall

	People[a]	Carnivore	Bobcat	Lynx	Black Bear	Food Waste
Coyote	-.830*	.854*	.063	.299	.386	-.116
People[a]		-.723*	-.083	-.380	-.380	.347
Carnivore			.095	.057	.232	-.025
Bobcat				.113	.113	.350
Lynx					.358	.264
Black Bear						.264

N = 16, [a]N = 14, *p<0.01

grey cells = 1-tailed, white cells = 2-tailed

In the summer and fall, we found a large,[7] negative correlation between coyote and human RARs [r=-.830, n=14, p<0.01], with low levels of coyote activity associated with high levels of human activity. We also found a large, positive correlation between coyote and carnivore activity levels [r=.854, n=16, p<0.01], with high levels of coyote activity

7 In my analysis, I categorize the strength of the relationship between variables according to SPSS guidelines (Cohen, 1988, as cited in Pallant, 2005).

associated with high densities of unidentifiable carnivore scats. Finally, there was a large, negative correlation between human and carnivore RARs [r=-.723, n=14, p<0.01], with high levels of human activity associated with low densities of unidentifiable carnivore scats.

3.4.2 Winter

Table 3. Spearman's rank order correlations between wildlife and human RARs in the winter

	People	Snowshoer	Skier	Hiker	Dog	Fox	Bobcat	Hare	Deer	Moose
Coyote	-.006	.122	-.103	-.146	-.612**	-.457*	-.113	.522*	.157	-.018
People		.037	.418	.553*	.479*	-.178	-.213	-.497	-.097	-.164
Snowshoer			.262	-.486*	-.116	.409	-.233	.272	-.540	.390
Skier				-.389	.285	-.089	-.038	.264	-.276	-.127
Hiker					.365	-.048	-.022	-.837**	.082	-.164
Dog						.464	.094	-.644*	.052	-.152
Fox							.007	-.200	-.504	.574*
Bobcat								-.165	.315	-.469
Hare									-.068	.301
Deer										-.589**

N = 10, **p<0.05, *p<0.10

grey cells = 1-tailed, white cells = 2-tailed

In contrast to our summer and fall results, in the winter we found no correlation between human and coyote RARs [r=.006, n=10]. However, there was a large, negative correlation between domestic dog and coyote RARs [r=-.612, n=10, p<0.05], with high levels of domestic dog activity associated with low levels of coyote activity. We also found a medium, negative correlation between coyote and red fox activity [r=-0.457, n=10, p<0.10], with higher levels of coyote activity associated with lower levels of fox activity. There was a large, positive correlation between coyote and snowshoe hare RARs

[r=.522, n=10, p<.10], with high levels of snowshoe hare activity associated with high levels of coyote activity.

We also found a number of correlations between different types of human RARs, between human and other wildlife RARs, and between various wildlife RARs. There was a large, positive correlation between human and hiker RARs [r=.553, n=10, p<0.10], a medium, positive correlation between human and dog RARs [r=.479, n=10, p<0.10], and a medium, negative correlation between snowshoer and hiker RARs [r=-.486, n=10, p<0.10]. We also found large, negative correlations between hiker and snowshoe hare activity [r=-.837, n=10, p<0.05], and between domestic dog and snowshoe hare activity levels [r=-.644, n=10, p<0.10]. There was a large, positive correlation between red fox and moose RARs [r=.574, n=10, p<0.10], and a large, negative correlation between moose and deer RARs [r=-.589, n=10, p<.05], with high levels of moose activity associated with low levels of deer activity.

3.5 Discussion

3.5.1 Summer and Fall

Previous studies on coyote activity patterns have observed both temporal and spatial displacement from human activity (Gehrt, Anchor, & White, 2009; Gehrt, Riley, & Cypher, 2010; George & Crooks, 2006). We found a large, negative correlation between coyote and human RARs. These results indicate a lack of co-occurrence between humans and coyotes during the summer and fall, the times of year when CBHNPC gets most of its visitors.

There was an even larger, positive correlation between the number of coyote scats and the number of unidentifiable carnivore scats found per kilometre. We found 42 unidentifiable carnivore scats on Skyline and all of them were full of choke cherries. There are no red fox in this part of CBHNPC, so these unidentifiable carnivore scats were made by either coyotes or black bear. Generally, speaking we were able to identify black bear scats based on volume. These unidentifiable scats were more likely to have been coyote scats, given that they were too small to obviously be black bear scats. The fact that there was no similar correlation between unidentifiable carnivore scats and species other than coyotes (i.e., bobcat, Canada lynx, or black bear), also suggests that many of the unidentifiable carnivore scats that we documented at our survey sites may have been coyote scats.

We also found a strong, negative correlation between human activity and unidentifiable carnivore scats. If unidentifiable carnivore scats were simply an artifact of human traffic destroying scats (thus making them unidentifiable to species), we would expect to have found a positive correlation between human and carnivore RARs, as opposed to the negative correlation that we did find. This finding suggests that variation in human activity levels between our survey sites did not significantly impact the number of scats that we were able to identify to species.

3.5.2 Winter

We found a large, negative correlation between domestic dog and coyote activity. George and Crooks (2006) found no relationship between coyote and dog activity in an urban park in California. Urban coyotes may be more inured to dogs than coyotes that live in more wild places, like CBHNPC. Other human-coyote conflict studies have found that coyotes may pose a risk to some small domestic dogs (Alexander & Quinn, 2011; Lukasik & Alexander, 2011; Timm et al., 2004; White & Gehrt, 2009). Our research findings suggest that dog walkers may be less likely to encounter coyotes, especially in areas where lots of people walk dogs. Also, people without dogs may be less likely to encounter coyotes in areas where lots of people walk dogs. It is noteworthy that the CBHNPC trail with the most severe history of human-coyote conflict (Parks Canada, unpublished data) is the one Park trail where dogs are not allowed.

There was a medium, negative correlation between coyote and red fox activity levels. Fox were only found in the eastern lowlands, whereas coyote activity was documented at every site throughout CBHNPC. This same lack of spatial overlap that we observed has been observed by many other researchers (e.g., Dekker, 1983; Gese, Stotts, & Grothe, 1996; Gosselink et al., 2003; Harrison, Bissonette, & Sherburne, 1989;

Johnson, Fuller, & Franklin, 1989; Litvaitis, 1992; Major & Sherburne, 1987; Sargeant & Allen, 1989; Sargeant, Allen, & Hastings, 1989; Voigt & Earle, 1983).

We found a strong, positive correlation between coyote and snowshoe hare activity levels. Snowshoe hare are an important prey species for eastern coyotes (Patterson, Benjamin, & Messier, 1998), and winter habitat selection of coyotes has been closely associated with snowshoe hare abundance (Murray, Boutin, O'Donoghue, 1994).

3.5.3 Other Spatial Activity Patterns

There was a large, positive correlation between human and hiker RARs, and a medium, positive correlation between human and dog RARs. A significant amount of the human activity in the Park during the winter time involved hikers (50% of the total). The correlation between human and dog RARs is not surprising, as there are no feral dogs in CBHNPC. The fact that there was not a stronger correlation between human and dog RARs is likely a reflection of the fact that many Park visitors do not bring their dogs with them.

We found a medium, negative correlation between snowshoer and hiker RARs. Overall, Park visitors wore snowshoes at sites where the snow depth and hardness made it easier to move in snowshoes and hiked where snowshoes were not necessary. There was a large, negative correlation between hiker and snowshoe hare activity. We observed most of the snowshoe hare activity at higher elevations, where there were fewer hikers (and more snowshoers and skiers) due to the greater snow depth. We also found a strong, negative correlation between domestic dog and snowshoe hare activity levels. Most of the domestic dog activity was observed at lower elevations, whereas – as we have already mentioned - most of the snowshoe hare activity took place at higher elevation sites.

We found a large, positive correlation between red fox and moose RARs. Red fox activity was only observed at 4 sites in the eastern lowlands, including 2 of the 3 groomed ski trails. Aside from Skyline Trail, the highest moose activity levels in the Park were observed on the groomed ski trails. Moose may be more active on groomed ski trails because they can conserve energy by moving on them; For the most part, moose could walk on the groomed ski trails without post holing. It is also possible that park trails were established along pre-existing wildlife trails.

We found a strong, negative correlation between moose and deer activity levels. Since their reintroduction to Cape Breton back in the 1940's, moose have gradually multiplied throughout the highlands (Bridgland, Nette, Dennis, & Quann, 2007). We only encountered deer activity at 2 lowland sites during the winter, and only on one occasion at each site, whereas we came across extensive moose activity at 9 of our 10 survey sites. This same lack of spatial overlap between moose and deer has been observed elsewhere within the province (Telfer, 1967) and has been variously attributed to a parasite, *Parelaphostrongylus tenuis* (Upshall, Burt, & Dilworth, 1987), and to moose having an energetic advantage in deep snow (Kelsall, 1969), such as is found in the Cape Breton Highlands.

3.5.4 Priority Sites for Future Human-coyote Conflict Monitoring and Management in CBHNPC

Overall, we observed a negative correlation between human and coyote activity levels in CBHNPC. However, there was more spatial overlap between human and coyote activity at some sites than others (Figures 5a & 5b). An exploratory data analysis (EDA) of our survey data suggests priority sites for future monitoring and human-coyote conflict management within CBHNPC.

We have ranked our sites according to 3 levels (Table 4). Priority 1 sites exhibit the greatest degree of co-occurrence between human and coyote activity, with either comparatively high levels of coyote activity (i.e., more than one scat or five tracks per kilometre of trail), or relatively high levels of human activity (i.e., more than fifty visitors per day). Priority 2 sites exhibit moderate co-occurrence between human and coyote activity with either very little coyote activity (i.e., less than one scat or 5 tracks per kilometre of trail), or very little human activity (i.e., less than fifty visitors per day). Priority 3 sites exhibit no co-occurrence between human and coyote activity, either because there were no humans or no coyotes detected at that site.

Table 4. Priority sites for future monitoring and management

Priority Level	1	2	3
Site Name	**Skyline**	Benjie's Lake	Bog Trail
	Acadian Trail	Corney Brook	Lone Shieling
	Chemin du Buttereau	Salmon Pools	MacIntosh Brook
	Cabot Trail[8]	*Warren Lake*	Le Buttereau
	Cheticamp Campground[1]		Cap Rouge
	Benjie's Lake		Old Cabot Trail
	MaryAnn Falls		Lake Trail
	Black Brook		*Paquette Lake*

Key: Regular Text = Summer & Fall Priority; *Italics = Winter Priority;* **Bold = Summer, Fall, & Winter Priority**

Clearly, these priority levels are arbitrary: while the rationale behind the priority 3 classification is self-evident, the dividing line between priority 1 and 2 sites is based on patterns in the data rather than any scientific rationale. There are sites that straddle the dividing line between priority 1 and 2 classifications, as well as sites with extremely high levels of human and/or coyote activity (e.g., Over 150 visitors per day, Over 20 coyote tracks/km of trail). These sites, in particular, warrant further attention.

The Cheticamp Campground showed a relatively high degree of spatial overlap between coyote and human activity in the summer, fall, and winter (Figures 5a & 5b). The campground is full of fruit trees and shrubs that provide ample forage for coyotes in the late summer and early fall. During that time of year, the vast majority of scats we documented within the campground and on surrounding trails contained fruit. Numerous Park visitors and staff, ourselves included, observed coyotes browsing on fruit in the

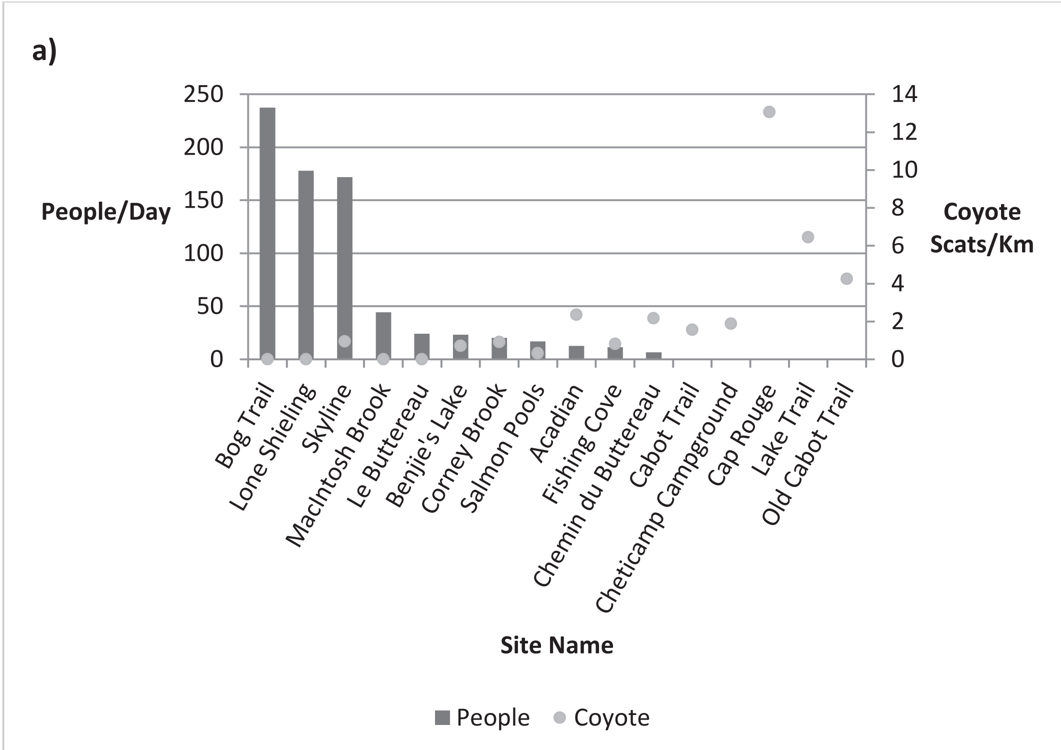
8 We lack quantitative data on human activity levels for the Cabot Trail and the Cheticamp Campground during the summer & fall, but still classified both as priority 1 sites based on high levels of coyote activity and observed human activity.

campground during the daytime. In related research (results not reported here), we tested the flight distances of two coyotes within the campground and found they moved off when approached at a normal walking pace to within 7 m and 30 m, respectively.

It is more difficult to explain high levels of coyote activity in the Cheticamp Campground in the winter. In comparison to the 9 other Park sites we surveyed in the winter, there was very little for coyotes to eat there (e.g., no snowshoe hare, limited small mammal track and sign, only 2 deer trails encountered the entire winter, no leftover fruit from the fall), and yet it had the third highest level of coyote activity out of the 10 sites we surveyed, despite having the highest levels of human activity that we documented in the CBHNPC that winter. In sum, the high degree of spatial overlap between human and coyote activity, the daytime sightings of coyotes, the extremely short flight distance of one of the coyotes we encountered, and the unaccountably high levels of coyote activity there in the winter, all indicate that the Cheticamp Campground warrants close scrutiny in the future.

The other site which may especially warrant future monitoring and conflict mitigation efforts by CBHNPC is the Skyline Trail. It also exhibited a relatively high degree of spatial overlap between coyote and human activity in the summer, fall, and winter. Skyline had the third highest level of human activity during the summer and fall, and was the only trail out of the 5 most popular trails we surveyed where we still detected coyote activity. During the summer, a number of Park visitors observed a coyote at close range while it apparently hunted voles alongside the trail. On several occasions in August, we heard a social group of coyotes, including pups, group-howl from a location slightly south of the trail.

In the winter, Skyline had the highest levels of coyote activity in the Park. It is an extremely windy, exposed trail and always had substantially less snow than our other highland sites. For that reason, it was likely easier for coyotes to move around there and to hunt small rodents and shrews. It was the only highland site where we encountered large areas of exposed ground during the winter. Furthermore, we observed more ermine activity at Skyline than at any other site in the Park (with the possible exception of



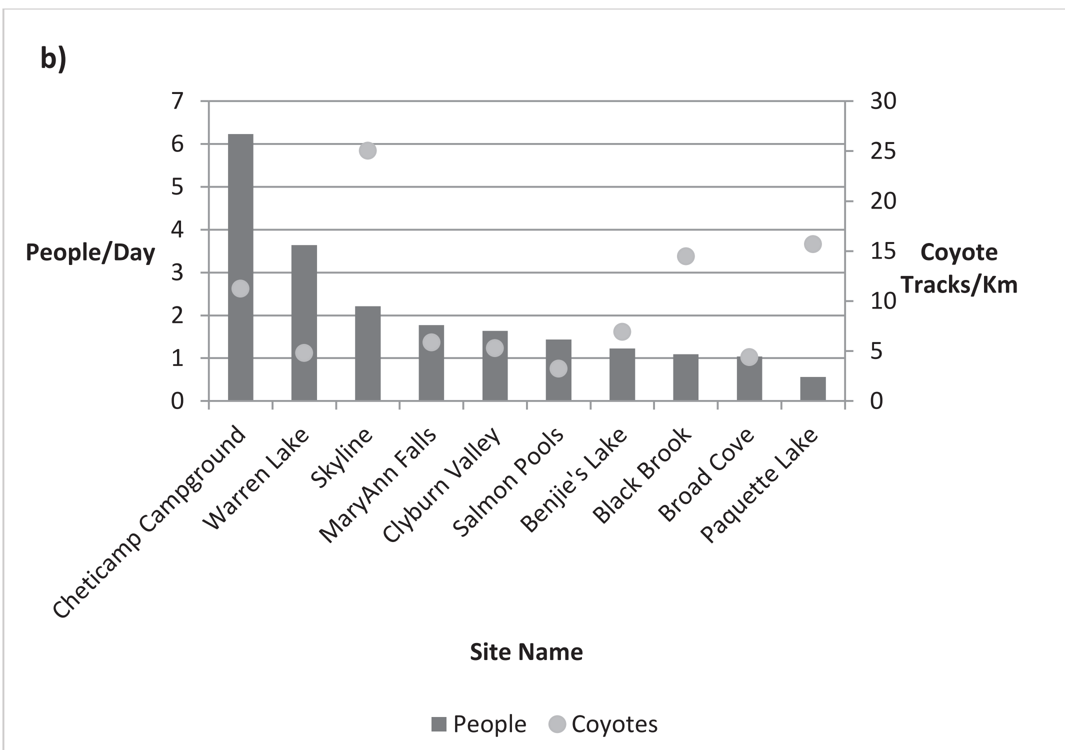


Figure 5. (a) Human and coyote activity in CBHNPC: Summer and fall, and **(b)** Human and coyote activity in CBHNPC: winter

Benjie's Lake), a potential indicator of high rodent and shrew densities, compared to other sites. Also, at Skyline we tracked the largest group of coyotes that we observed travelling together in CBHNPC that winter: 5 individuals. Altogether, the extremely high levels of coyote activity during the winter and continued activity during the summer and fall, in spite of the extremely high number of hikers, as well as the history of human-coyote conflict at this site and continued daytime encounters with habituated coyotes, all indicate that this trail should continue to be monitored closely.

3.6 Conclusion

Our research findings suggest that coyotes in CBHNPC are least active in areas of the Park with high levels of human activity. As such, our results yield evidence that CBHNPC does not have a coyote problem with respect to frequent encounters between humans and coyotes, per se, but rather that specific sites in the Park have problems. Our surveys identified hot-spots of human and coyote activity and may help prioritize future efforts to mitigate conflict in the CBHNPC. For example, CBHNPC intends to implement a hazing protocol in the near future, and our research suggests locations where hazing efforts could be concentrated to maximize their potential effect. Furthermore, our data and methods could be used to assess the efficacy of a hazing protocol at decreasing levels of co-occurrence between humans and coyotes at key sites in CBHNPC.

When it comes to human-wildlife conflicts, especially those that involve species-at-risk, researchers and conflict biologists are frequently confronted with very site-specific questions for which parametric statistical analyses are not appropriate. Our analysis provides a successful example of how non-parametric statistics may be used to address such site-specific questions. Furthermore, our analysis provides an example of how EDA may be employed to address extremely site-specific questions involving small sample sizes, as is often the case in human-wildlife conflicts. Our analysis also demonstrates how anecdotal evidence, such as that discussed in our EDA of priority sites, may be used to supplement the insights provided by more formal, objective analysis.

Additionally, this research provides an example of how multiple noninvasive methods may be employed and integrated to study human-wildlife conflict. Although using a single survey method may be tempting in order to avoid the challenges of integrating multiple methods, it is often not the best way to assess dynamics between multiple species because some noninvasive methods are more effective at detecting certain species than others. Also, while invasive methods may be used to great effect in human-wildlife conflict research, in many cases they may be too costly, both in terms of money and their potential impacts on the welfare of rare and endangered species. As such, it is worth trying noninvasive alternatives.

CHAPTER 4: Discussion

4.1 Primary and Secondary Objectives

The primary objectives of this thesis were to assess the relationships between coyote, human, domestic dog, and other select wildlife activity levels in CBHNPC, and to identify times of year and sites within CBHNPC with the greatest degree of spatial overlap between human and coyote activity. These primary objectives have been met. The secondary objectives of this thesis were to examine the role that indirect feeding may play in human-coyote conflict in CBHNPC and to examine how moose carcasses may affect spatial patterns of coyote activity in the Park. These secondary objectives will be addressed in the following two sections.

4.2 Indirect Feeding and Food-conditioning

In 1981, a 3-year-old girl was killed by a coyote in Glendale, California (Howell, 1982). This was the first documented case of a coyote fatally attacking a human. The following year, Robert Howell published a paper on the history and management of coyote attacks in Los Angeles County, California. In this paper, Howell identified garbage, pet food, small pets, vegetable gardens, and wildlife feeding as probable root causes of the conflict. He based his assessment on a combination of personal observations and experiences, field notes from trappers, and stories told by local residents. Subsequent papers on coyote attacks have also suggested that human-associated foods contribute to human-coyote conflict and have recommended that managers take measures to discourage wildlife feeding and reduce coyotes' access to anthropogenic foods (i.e., Alexander & Quinn, 2011; Baker & Timm, 1998; Bounds & Shaw, 1994; Carbyn, 1989; Lukasik & Alexander, 2011; Lukasik & Alexander, 2012; Timm et al., 2004; White & Gehrt, 2009). In other human-carnivore conflicts, human-associated foods have also been implicated in attacks (e.g. Burns & Howard, 2003; Herrero, 2003; Herrero & Fleck, 1990; Peterhans & Gnoske, 2001; Saberwal et al., 1994).

In my analysis, I tested for co-occurrence between coyote activity levels and human-associated food densities using a 1-tailed Spearman’s rank order correlation (see section 3.2 for a more in depth discussion of my methods). I found a small, negative correlation between coyote activity (as measured by scats per kilometres of trail) and human-associated foods (as measured by human-associated food items and food containers per kilometre of trail) [r=-.116, n=16] that was not significant (Table 2). The vast majority of human food items and food containers I encountered were alongside the Cabot Trail (89%), as opposed to in campgrounds (0%), or on Park trails (11%). The only trail where I found more than one human-associated food item on was Skyline (9%; Figure 6). It is worth noting that Skyline has an extensive history of human-coyote conflict (Parks Canada, unpublished data).

Near the western entrance to CBHNPC, I found food containers with bite marks made by canine teeth. Unfortunately, I was unable to find a clear set of bite marks and so could not use bite forensics to identify the species that had been chewing on these food containers. As there are no feral dogs, red foxes, and very few raccoons in that area of the Park, it was most likely either black bears or coyotes that were chewing on this garbage. Although I found several scats that contained human-associated food items (e.g., a granola bar wrapper, plastic) I was unable to identify these scats to species because domestic dogs are permitted on most Park trails and there were never enough natural food items in the scats to tell whether the scat was made by a wild canid or a domestic one. Furthermore, my surveys were unable to detect more digestible anthropogenic foods that may have been consumed by coyotes. In sum, while human-associated foods may attract and be consumed by some coyotes, they do not appear to be influencing spatial patterns of coyote activity in CBHNPC.

In addition to testing for co-occurrence between coyote activity and human-associated food waste, I used a 1-tailed Spearman's rank order correlation to test for co-occurrence between spatial patterns of human-coyote conflict (Parks Canada, unpublished data), and human-associated food densities. Instead of calculating RARs for human-coyote conflicts at each of my survey sites, I simply added up the total number of human-coyote conflict incidents that had taken place at each site. I found a strong, positive correlation between spatial patterns of human-coyote conflict and human-associated foods [r=.756, n=16, p<.01], with high levels of conflict associated with high densities of

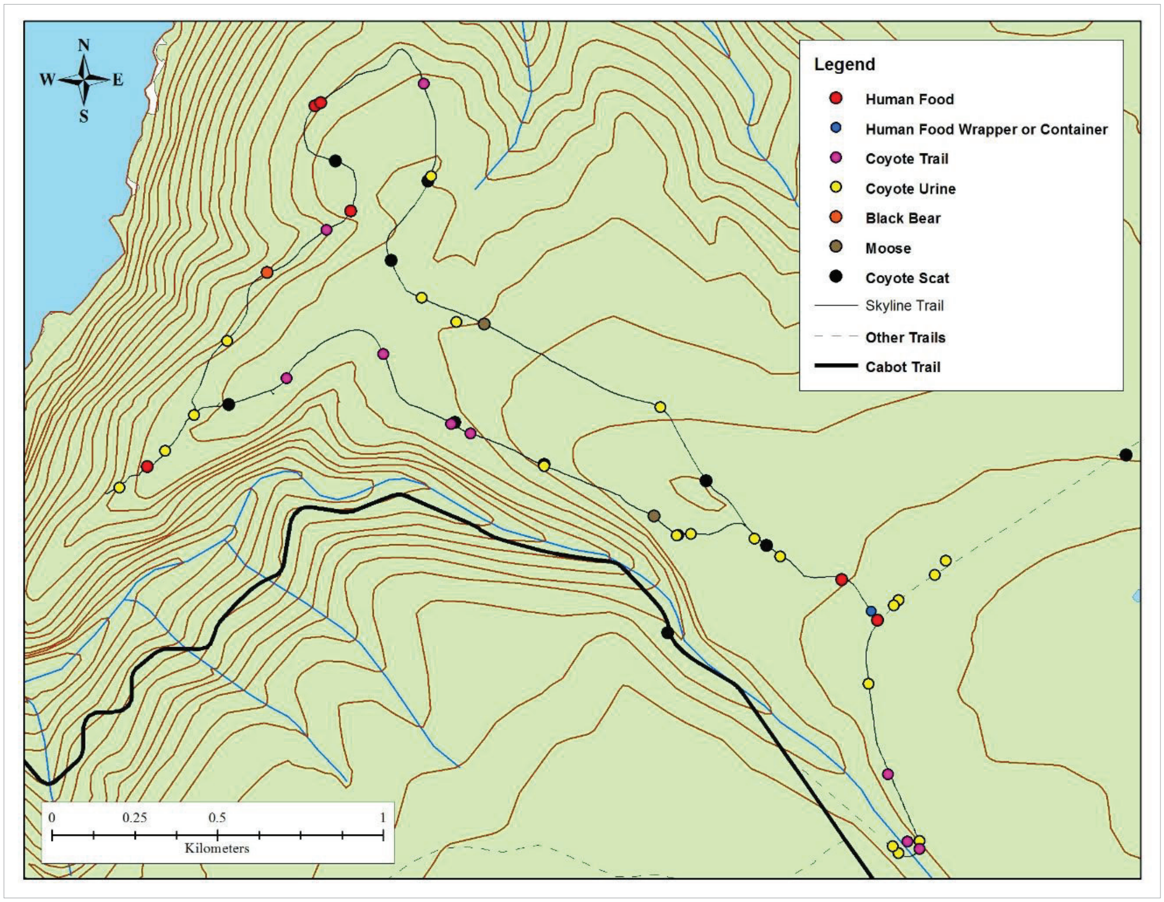


Figure 6. Trash map of Skyline Trail, CBHNPC

anthropogenic food waste. 46 % of human-coyote conflict incidents took place alongside the Cabot Trail (14 out of 30 incidents), which is also where I found most of the food waste. Many more people drive and bicycle the Cabot Trail through CBHNPC than hike or camp in CBHNPC. As such, the correlation between human-coyote conflict incidents and human-associated foods may actually reflect the connection between human-coyote conflict and the Cabot Trail, where high levels of human activity may increase the probability of an encounter. Also, the Park data on human-coyote conflict incidents is likely incomplete and may contain errors (see section 4.4 for a more in depth discussion). Therefore, these research findings should be interpreted with caution. Other recent research has observed a spatial trend between reported human-coyote conflict incidents and anthropogenic food items in coyote scats (Lukasik & Alexander, 2011).While I found no correlation between human-associated foods and spatial patterns of coyote activity, anthropogenic foods may still influence spatial patterns of human-coyote conflict.

The potential link between human-associated foods and coyote aggression towards people has a firm basis in animal psychology. Food is a primal motivator for all animals and, as such, functions as a very effective tool for conditioning behaviour. Repeated exposure to human-associated foods with no negative consequences may lead to food-conditioning,[9] whereby coyotes associate people with food. The sight, smell, and sound of people may come to function as a conditioned stimulus for coyotes. As primarily visual creatures, we are somewhat handicapped in our ability to grasp the varied circumstances under which food-conditioning may occur in other species. Scent is a dominant sense for coyotes, and as such, they do not need to see or hear people to develop an association between food and humans. A coyote that comes across a pastry, chocolate bar, banana peel, or even an empty take-out box, along a deserted section of the Cabot Trail can smell not only the food but the scent of the human that handled that food, and may, over time learn to associate people with food through this sort of indirect feeding.

Further research needs to be conducted on the connection between human-associated foods and coyote attacks. Ideally, research would involve a spatial and temporal analysis of human-coyote conflict incidents, anthropogenic food availability, and human-associated food use by coyotes. Also, further research needs to be conducted on the learning process of habituation,[10] association (i.e., food-conditioning), and avoidance in wildlife (Herrero et al., 2005; Knight & Cole, 1991), as well as the relationship between habituation and associative learning (Knight & Temple, 1995). While habituation does not necessarily lead to food-conditioning, and habituation - in the absence of food conditioning - may not pose the same risks to human safety (Herrero et

[9] Food-conditioning is a form of associative learning, whereby animals learn to associate a conditioned stimulus (e.g., people) with an unconditioned stimulus (e.g., food).

[10] In the context of human-wildlife conflict, habituation is a process whereby repeated exposure to humans without negative consequences causes wildlife to lose its fear of people.

al., 2005), habituation may still increase the odds of food-conditioning taking place by increasing the chances that coyotes will encounter anthropogenic foods.

In human-coyote conflicts, the need for further research on both the relationship between human-associated foods and conflict, and the behavioural mechanisms that may shape this relationship, is not a valid excuse for inaction in the meantime. Despite the need for further research, research to date provides more than enough indication that CBHNPC should pay close attention to indirect feeding via roadside garbage and the potential for food-conditioning. As illustrated by a roadside survey adjacent to several Park trails (Figure 7), there is a significant amount of food waste alongside the Cabot Trail. Prior to conducting the roadside survey illustrated in this map, CBHNPC staff indicated that no one had collected trash along the Cabot Trail in a year or more. Roadside trash collection could be an important part of future human-coyote conflict mitigation strategies in CBHNPC. In conversation with Park staff and Park visitors, a number of people indicated that it had never occurred to them that organic litter (e.g., banana peels, apple cores, egg shells, chips etc.), even though it is biodegradable, still should not be thrown out the car window or off into the woods alongside a trail. This knowledge gap could be addressed in future public education campaigns. Finally, coyote habituation - despite the fact that it may not pose an intrinsic risk to visitor safety - is still cause for concern. As already discussed in 3.5.4, coyotes in the Cheticamp Campground and on the Skyline Trail show clear evidence of habituation. Although coyotes may be attracted to these sites by natural food sources (e.g., wild fruit in the campground, small mammals at Skyline), the potential for these coyotes to be exposed to human foods and for food-conditioning to take place is cause for concern. Although the average Park visitor is not afraid of coyotes and some have commented that they would be happy to see a coyote during their visit to CBHNPC (Carly Sponarski, unpublished data), it might be worthwhile for the Park to encourage visitors to create negative - as opposed to neutral - experiences for coyotes they encounter during their visit, and to advise visitors on how best (and safely) to do so.

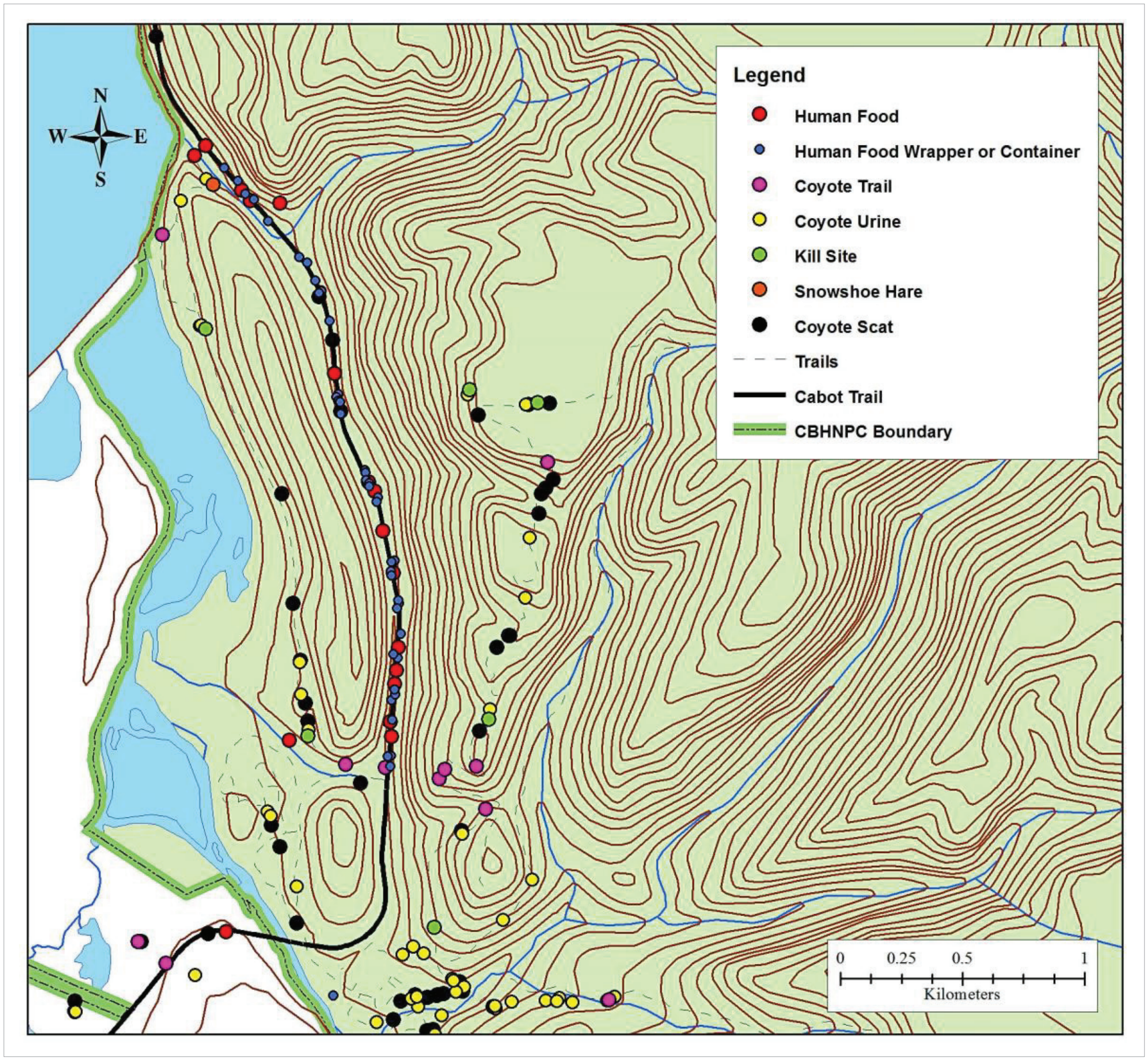


Figure 7. Trash map of the Cabot Trail at the western entrance of CBHNPC

4.3 Moose Carcass Disposal

Although coyote and moose activity levels show no significant correlation, moose carcasses may significantly influence coyote activity patterns within the Park. Andelt & Hein (1996) found that deer carcasses attracted coyotes to less familiar parts of their home ranges and kept them there for extended periods of time. Moose carcasses are likely to have a similar effect on coyote behaviour.

One moose carcass was discovered during the summer and fall scat surveys on a remote section of trail that was closed to the public (i.e., the Old Cabot Trail). The moose appeared to have died from a 20 m fall off of a bridge. There were signs of both coyotes and black bears feeding on the carcass, in the form of numerous scats full of organ meats and moose hair in the surrounding area. 4 other moose carcasses turned up in CBHNPC over the same survey period: one poached moose, and 3 others that were most likely killed by motor-vehicle collisions. We discovered one of the moose carcasses approximately 100 m from the Cabot Trail, where we were led by a social group of coyotes vocalizing at dusk. CBHNPC staff discovered and disposed of the other 3 moose carcasses at different sites. Disposal sites were within 260, 85, and 680 m of the Cabot Trail, respectively, with the last disposal site adjacent to a trail that is groomed for skiers in the winter.

Two moose carcasses were discovered during the winter snow tracking surveys. In both cases, coyote tracks lead us directly to the carcasses and there were clear feeding signs (i.e., coyote track mats surrounding the moose carcass, fresh coyote scats nearby with moose hair in them). One moose carcass was found 20 m from the Clyburn Valley Trail, the other 30 m from the Black Brook Trail. Both moose carcasses significantly increased the amount of coyote activity on adjacent human trails. On the Clyburn Valley Trail, 12 coyote trails were found intersecting the human trail along a 200 m stretch of the human trail west of the moose carcass. The previous four surveys had detected 2, 2, 0, and 0 coyote trails, respectively, none of them on that particular section of the trail. On the Black Brook Trail, 58 coyote trails were found intersecting the human trail, as well as 8 coyote track mats. All but 2 of the coyote trails that we found after the moose carcass appeared were within 500 m up- or down-trail from the moose carcass. Previous surveys had detected 3, 1, 1, and 12 coyote trails, respectively. Once again, none of the previously detected coyote trails were along that particular section of the human trail. Also, a rare daytime image of a coyote was captured on a nearby remote camera after the moose carcass appeared.

In any given year, CBHNPC needs to dispose of a number of moose that have died in collisions with motor-vehicles, been killed by poachers, or died of other unknown causes. The Park has several sites where they have routinely disposed of moose carcasses over the years. These sites are essentially bait stations, and these carcasses represent a form of indirect feeding. Spatial patterns of attacks have been closely linked to sites where wildlife have been routinely fed in the past (Saberwal et al., 1994). As such, CBHNPC should carefully assess the location of current moose carcass disposal sites. The results of our winter snow tracking surveys indicate that these sites should be more than 500 m - at a minimum - from the nearest road, trail, or other visitor-use area.

4.4 An Analysis of Human-coyote Conflict Incidents in CBHNPC

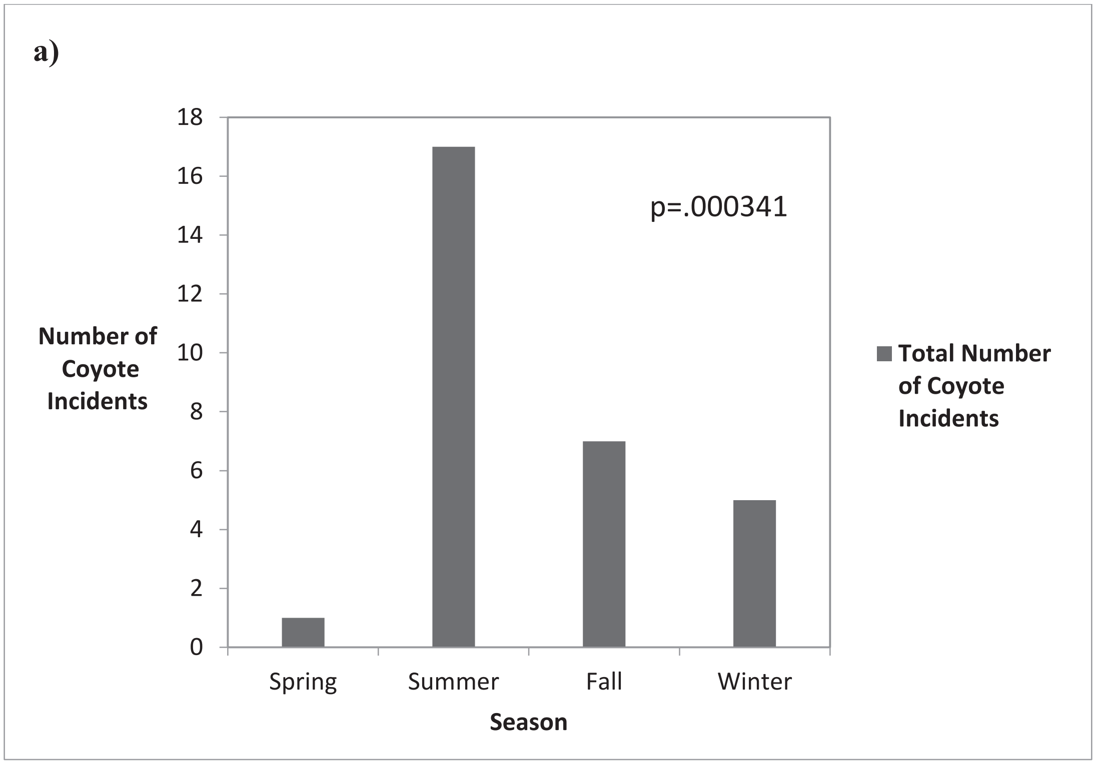
As mentioned in the introduction, CBHNPC has kept records of human-coyote conflict incidents within the Park since 2003 (Parks Canada, unpublished data). Unfortunately, due to the lack of a systematic process for collecting reports and documenting incidents, these records are of limited value to both researchers and CBHNPC. Hence, I did not incorporate this data into either my survey design or my analysis in Chapter 3. Nonetheless, given that these records represent the only history of human-coyote conflict available to date, it is worth taking a closer look. However, it is important to exercise extreme caution in the interpretation of this analysis, as the data set this analysis is based on is likely incomplete. Coyote incidents of different significance are given equal weight. For instance, one incident where a single group of hikers passed a coyote while hiking on a trail and another incident where many people saw a coyote in a campground over the course of several days each triggered a single incident report; clearly the latter incident was more significant, but that significance is not clearly reflected in either CBHNPC's reporting system or this analysis. The aforementioned issues are amplified by the fact that this analysis involves an extremely small data set (30 incidents in total) where small differences may easily take on undue significance.

For the purpose of this analysis, coyote incidents were classified according to the 3 categories of human-coyote conflict determined by CBHNPC (and outlined in the introduction) - fearless, aggressive, or attack - and according to the time of year the incident took place. I delineated the seasons according to local culture and climate: Spring (April-May), summer (June through Labour Day weekend), fall (the Tuesday after Labour

Day weekend through November), and winter (December-March). Other researchers have analyzed human-coyote conflicts according to the seasonality of coyote life history (Grubbs & Krausman, 2009; Lukasik & Alexander, 2011; Morey, Gese, & Gehrt, 2002; White & Gehrt, 2009), e.g., breeding, pup-rearing, dispersal etc. I elected to analyze human-coyote conflict from the perspective of tourist seasons instead, as this perspective may be more useful to CBHNPC in understanding and managing the human dimensions of this conflict.

The relationship between frequency of coyote incidents and seasonality was investigated using a chi-square test for goodness of fit. Preliminary analyses were performed to ensure no violations of the assumptions of expected frequency (i.e., 80% of cells have expected frequencies of 5 or more, and no cells have an expected frequency of less than 1). A chi-square test for goodness of fit revealed significant seasonal variation in the frequency of coyote incidents (x^2=18.533, *df*=3, *p*=.000341). Although CBHNPC lacks year-round data on human activity patterns in the Park, the frequency of coyote incidents in the Park roughly reflects seasonal patterns of human use, with the majority of incidents taking place in the summer (Figure 8a). As such, seasonal patterns in human-coyote conflict may well be an artifact of seasonal patterns of human use. That said, the summer is also the times of year when coyote pups are becoming more independent (e.g., July- September) (Parker, 1995). Juvenile coyotes are perhaps less likely to exhibit wariness towards humans than adults, and juveniles have been implicated in many fearless encounters in the Park (Parks Canada, unpublished data). Also, while pups are not yet independent, adult coyotes may be more motivated to overcome any innate wariness of humans in their search for food.

I investigated the relationship between type of coyote incident and seasonality using Fisher's Exact Test, as preliminary analyses revealed that expected frequencies were too small for a chi square test. There was no statistically significant association between type of incident and season (*p*=.855) (Figure 8b). Overall, the majority of conflict incidents in CBHNPC have been classified by CBHNPC as 'aggressive' (16 out of 30). For a variety of reasons, it is surprising that there would be more aggressive incidents



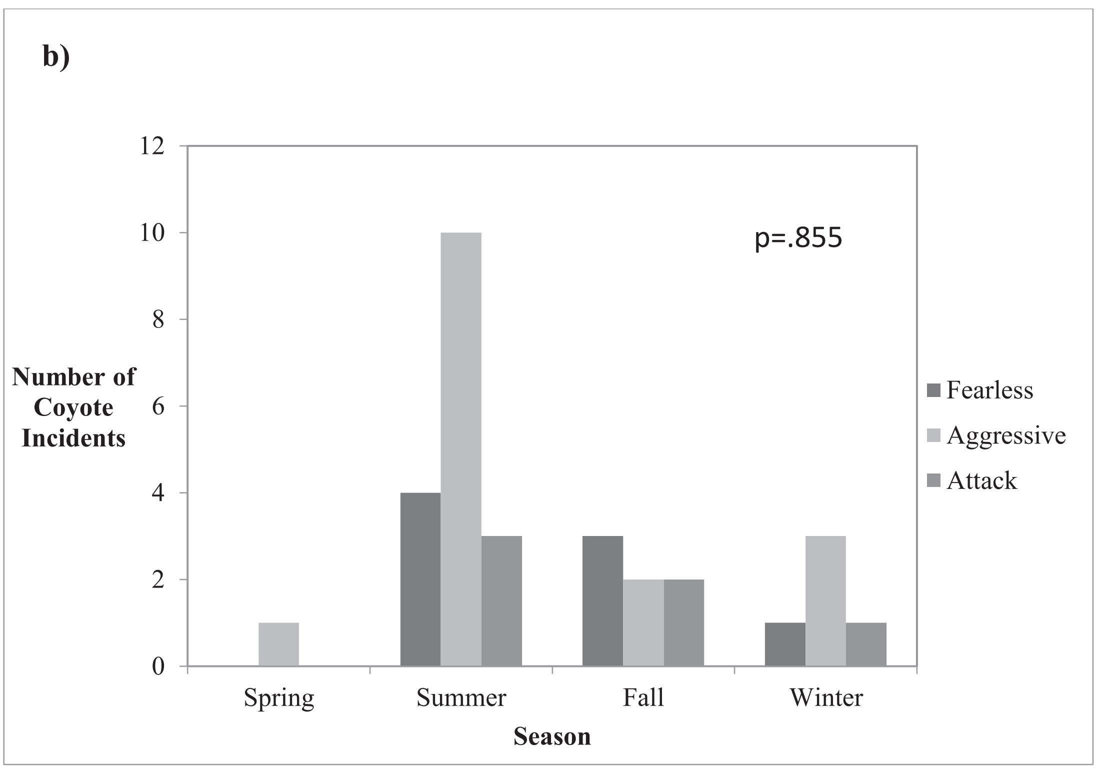


Figure 8. (a) Total number of coyote incidents in CBHNPC from 2003-2012 by season, and **(b)** Total number of coyote incidents in CBHNPC by type and season.

than fearless ones. In other human-coyote conflict studies, the majority of reported conflict incidents were coyote sightings (Lukasik & Alexander, 2011), and CBHNPC's definition of a fearless incident most closely resembles that of a coyote sighting. The predominance of aggressive incidents may reflect a reporting bias at the Park, where visitors fail to report encounters with 'fearless' coyotes because they came to CBHNPC to see wildlife and therefore do not perceive encounters with coyotes that are not afraid of them as cause for concern. On the contrary, habituated coyotes may be seen positively from a wildlife viewing perspective.

4.5 Future Research

Invasive methods can have wide-ranging impacts on the welfare and behaviour of wildlife (Alibhai & Jewell, 2001; Alibhai, Jewell, & Towindo, 2001; Cattet et al., 2006; Cattet, Boulanger, Stenhouse, Powell, & Reynolds-Hogland, 2008; Dyck et al., 2007; Moorhouse & Macdonald, 2005; Tuyttens, Macdonald, & Roddam, 2002). To date, research on the impacts of invasive methods has mainly focused on species of conservation interest and/or reproductive behaviour. One such study found that repeated captures significantly impacted the ranging behaviour - and therefore fitness - of black bears and grizzly bears (Cattet et al., 2008). This particular study hints at the potential of invasive techniques to impact behaviour relevant to human-wildlife conflicts. For instance, if invasive survey techniques influence wildlife movement patterns, this may influence the probability of people encountering wildlife.

As such, further research needs to be conducted on the ways in which invasive research methods may impact how wildlife relate to people. Until such research has been conducted, researchers cannot safely assume that invasive techniques have little or no impact on animal behaviour within the context of human-wildlife conflicts. In the interim, invasive methods should be employed with due caution and the understanding that such methods may bias research findings. In urban contexts, human-wildlife conflict biologists may be able to make the argument that wildlife are already so habituated to humans that invasive techniques are unlikely to significantly alter their behaviour towards or around people. However, this argument is less compelling in rural and wilderness contexts, where wildlife have fewer opportunities to interact with people and may easily avoid humans.

4.6 Conclusion

The main purpose of this study was to conduct a preliminary assessment of the biophysical dimensions of human-coyote conflict in CBHNPC and to discuss possible management implications. In conjunction with this principle intent, I aimed to develop a methodological approach for studying human-coyote conflict that might be of future use to CBHNPC and to the study of other human-wildlife conflicts. While this research has elucidated some of the broad-scale dynamics between people and coyotes in CBHNPC, suggested a number of sites where CBHNPC could focus future research activities, and lent itself to more specific recommendations to mitigate conflict in the interim, it is clear that there are no simple answers..

In any discussion of human-coyote conflict, it is easy to lose sight of the fact that human-coyote conflict incidents are exceptionally rare. A recent review of coyote attacks in Canada and the U.S. found reports of only 142 attacks (White & Gehrt, 2009). In the interest of adding perspective to this figure, approximately 200,000 serious dog attacks are reported every year in the U.S. alone (CDC, 1997). Overall, people and coyotes manage to coexist without incident in CBHNPC and elsewhere. While successful co-existence is a positive state, it is also a state that makes it difficult to untangle the complex circumstances that lead to adverse encounters and to settle on a reasoned course of action that has some hope of redressing and mitigating conflict. A key aspects of human-coyote conflicts (as well as other human-wildlife conflicts) is that the conflict originates as much - or, in some cases, more - in our minds, as it does in the outside world.

Public officials are under a tremendous amount of pressure to do something, anything, to address peoples' concerns. These past four years have been an extremely challenging time for wildlife managers, coyote biologists, and anyone else who cares about coyotes and people. Even in the absence of knowledge about the nature of the conflict or what management actions might prove effective, doing nothing is not an option. Faced with people's fears and concerns, wildlife conflict managers may resort to management actions that they know will not resolve the problem. The coyote bounty in Nova Scotia is one example of this kind of ineffective response. Although coyote bounties have proven ineffective at reducing and/or eliminating coyote populations in Nova Scotia and elsewhere (Parker, 1995), and there is no evidence that they effectively address any biophysical dimension of human-coyote conflict, they have been successful in one sense: coyote bounties make the uninformed public feel that something is being done to address their concerns. Now, it is time to do something that both addresses people's concerns and that might serve to avert future conflict.

Appendix A: Scat and Snow Tracking Survey Forms

Form A-1. Scat survey session form

Session Form		
Date		Notes:
Tracker Name(s)		
Site Name		
Place Start		
Place End		
Survey Effort		
Time Start		
Time End		
Distance Surveyed		
Weather		

Form A-2. Scat survey form

SCAT SURVEY FORM			
GPS		**Context**	
ID #		Trails & Junctions	
Time		Raised Surface	
20 T		Scrape or Scratch	
UTM		Latrine	
Error		Bridge	
Description		**Interpretation**	
Width		Species	
Length		Confidence	
Pieces?		Age	
Content		**Documentation**	
Scent		Photographer	
Substrate		Photo #	
Twisted?		Collected?	
Tapered Ends?		**Notes**	
Segmented?			
Colour			
Consistency			
Covered?			

Form A-3. Snow tracking survey form

SNOW TRACKING SURVEY FORM

Site Name: __________________ **Weather Conditions:** ___________________________

Date: ______________ **Days Since Last Snow:** ______ **Snow Depth:** _____________

Snow Condition: Powder / Drifting / Freeze-Thaw Crust / Wind-packed Snow /

Ice Crust / Snow/Slush

Time Start: _________ **Time End:** ________ **Distance Surveyed:** _________

Number	Type	Easting	Northing	Error	Species	Confidence	Age	Snow Quality
Notes								
Notes								
Notes								
Notes								
Notes								
Notes								

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