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## Trophic Relationships Among Caribou Calf Predators in Newfoundland

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TROPHIC RELATIONSHIPS AMONG CARIBOU CALF PREDATORS  
IN NEWFOUNDLAND

A Thesis Presented

by

CHRISTOPHER J. ZIEMINSKI

Submitted to the Graduate School of the  
University of Massachusetts Amherst in partial fulfillment  
of the requirements for the degree of

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## **DEDICATION**

For all the people and companions we have lost

**ABSTRACT**

TROPHIC RELATIONSHIPS AMONG CARIBOU CALF PREDATORS  
IN NEWFOUNDLAND

MAY 2016

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Using specially trained scat detection dogs we located fecal samples from black bear (*Ursus americanus*) and coyote (*Canis latrans*) throughout three study areas in Newfoundland, Canada, to describe these predators diet. Our sampling efforts were designed around seasons which were important to woodland caribou (*Rangifer tarandus caribou*) calving and resource use. We identified hairs microscopically to prey species and grouped other remains to facilitate our analysis. Bear exhibited an omnivorous diet throughout the study areas, ecological seasons and inside and outside the caribou calving grounds while coyote were limited to caribou, moose and snowshoe hare.

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# CHAPTER 1

## STUDYING FOOD HABITS OF CARNIVORES - A REVIEW

### Abstract

Previous research in Newfoundland, Canada, identified black bear (*Ursus americanus*), coyote (*Canis latrans*) and lynx (*Lynx canadensis*) as primary predators of caribou, and in particular their calves. Our research project was designed to investigate food habits of these primary predators of caribou during the calving (1 – 27 June) and summer (28 June – 31 August) seasons of 2009 and 2010 in Newfoundland. We considered how to best collect fecal samples for microscopic analysis of prey items and how to spatiotemporally design our effort. We began by exploring the potential implications of intensive selection pressure on seasonally abundant prey items by a specific subset of a predator population. Utilizing our previous experience we located and trained detector dogs to survey for predator scats within and outside caribou calving areas in three study areas. Additionally, scats collected by our detector teams were genetically tested to identify species and individuals for predator occupancy and abundance estimates. Initially, our detection dogs were trained to target scats of black bear, coyote and lynx. However due to a paucity of lynx training samples and in-field reinforcement, lynx were omitted from the analysis due to an insufficient sample size. We collected over 800 samples; 393 from bear and 414 from coyote. The canines were successfully able to accurately identify our target species as evident by the high rate of validation from genetic testing in 2009 (bear = 95% and coyote = 91%) and 2010 (bear = 97% and coyote = 91%). To assess likelihood of finding a sample (N = 214) without the canine, we categorized samples as impossible (77%), low (13%), medium

(10%) or high (1%). Samples scats represented a multitude of individuals for both bear (N= 71) and coyote (N = 79) and both sexes were well represented for both species. Additionally, during the detection surveys we were able to locate a variety of mortality or kill sites, including those of caribou calves.

A literature review of scat analysis methods, sample size constraints and detector dog methodology are also included, as well as an in-depth discussion of detector dog training.

## **Introduction**

Understanding fundamental questions concerning a species' ecology begins with understanding their food habits. There are numerous approaches to answer dietary questions and each method possesses unique advantages and disadvantages, however a common obstacle in these studies is in collecting samples sufficient to portray the population's diet. Spatial and temporal constraints require intensive yet timely sampling approaches. Sampling that is reliant on stomach contents can blur ethical lines if animals are killed solely for dietary analysis or if the study species occur in low densities or are threatened. Furthermore, gastrointestinal samples can be biased if capture is induced by baiting as those food items will be more prevalent in the digestive tract (Litvaitis 2000). Likewise, opportunistic fecal sampling is fraught with difficulty in obtaining samples as human observers can bias search effort by capturing conspicuous samples in easy to search locations. Employing detection dogs can circumnavigate these challenges by providing samples that are difficult to locate which cover a diversity of habitats in a timely and repeatable fashion.

Domestic dogs (*Canis lupus familiaris*) have a superior sense of smell and can detect minute concentrations of odor, discriminate between various scents and locate the source of a target odor. Dogs have been trained to assist humans since domestication and selective breeding

has enhanced traits which facilitate this cooperative relationship. From applications of a military and policing nature to more recent uses such as cancer detection, therapy, and searching for bed bugs, the use of detection dogs is increasingly applied to biological pursuits.

### **Food Habits and Sample Size**

Foraging habits of wild animals are recorded via direct observation, capture and inspection of gastro-intestinal remains or through fecal analysis; however, fecal samples are the most readily abundant and nonintrusive method for collecting and analyzing food habits (Litvaitis 2000). These data assist managers of sympatric carnivore species to establish habitat occupancy, evaluate niche overlap, and determine presence of interspecific competition (Fedriani et al. 2000). Constraints intrinsic to analytical approaches of food habits limit comparisons across spatial, temporal and population scales and are susceptible to bias in quantification of dietary components (Reynolds and Aebischer 1991). Specifically, fecal analysis is criticized for the inability to assess energetic component of food items, the omission of low frequency prey items due to differential digestibility, and inability to measure dietary contribution by volume (Litvaitis et al. 1994). Initially, discrepancies in food habit analysis from different sample sources were attributed to the improved resolution provided by the analysis of gastro-intestinal samples, however recent studies indicate no bias in prey occurrence when comparing fecal and stomach contents provided a sample size over 100 (Robitaille and Laurence 2007).

Limitations on diet analysis and inference generally involve sample size. Therefore, the main challenge in establishing a robust sample set relies in the ability to collect a large number of samples at various or varying scales. A small sample size can limit statistical inference when sampled scats are not representative of all available scats and as a consequence does not measure the diet of the study group (Reynolds and Aebischer 1991). Additionally, between populations,

comparison tests will lack power and infrequent prey items can be absent (Trites and Joy 2005). Dietary analysis is strongly influenced by the number of prey species consumed; for example, detecting relationships between populations consuming 3 prey species requires 179 scats, but a diverse consumption pattern of 15 prey species requires only 51 scats (Trites and Joy 2005). Mukherjee et al. (1994) recommended a minimum of 80 leopard (*Panthera pardus*) scats for accurate diet evaluation, provided collection occurred at a local scale over a defined timeframe to limit influence of spatiotemporal variation in distribution of prey. Bias in indices of overlap increase with number of resources (prey) available and decrease with increased sample size (Litvaitis 1994). Azevedo et al. (2006) corroborated benefit and power of sample size in breadth analysis as a temporal dietary shift was likely an artifact of small sample size.

In addition to a large sample size, adequate sampling accounts for temporal fluctuations in abundance and availability of resources and should incorporate as many sympatric carnivores occupying similar trophic levels to prevent detection of egregious responses, underestimation of variability and misdiagnosis due to uninvestigated relationships and influence (Azevedo et al. 2006). Essentially, dietary variation is a function of prey distribution and a species general pattern of consumption. Results can be skewed if a large proportion of analyzed samples reflect a specific individual's preference, therefore, maximizing the number of individuals sampled prevents population wide skewing of dietary relationships yet maintains the ability to identify unique foraging strategies over time and space.

### **Individual Dietary Variation**

Foraging strategies vary at multiple scales among species; therefore, assessing resource utilization at the population level can ignore individual variation. Factors influencing intra-population niche variation and inter-individual preference vary widely, but include: habitat

heterogeneity and the related influences on prey abundance; location of home range within a matrix of differential habitat quality; learned behavior; energetic requirements; morphological features; and adaptive response which can lead to speciation (Wilson 1998, Prugh et al. 2008). Bolnick et al. (2003) modeled individual level niche variation as an interaction of three main effects: sexual dimorphism, ontogenetic niche shift, and resource polymorphism, with the error term representing individual diet variation not attributed to the aforementioned classes. Therefore, our interpretation of niche diversity can be shaped by the presence and proportion of specialized individuals within a population and by the degree of deviation from 'normal' patterns of consumption. Information detailing niche variation or specialization can be of particular importance when individual predators or smaller groups of individuals disproportionately influence prey populations.

Ross et al. (1997) assessed cougar (*Puma concolor*) winter diet composition by investigating kill sites located with telemetry data and snow tracking in the Rocky Mountains of southwestern Alberta. Ungulates comprise >99% of prey biomass consumed by cougars and investigation of 320 kill sites identified 29 bighorn sheep (*Ovis canadensis*) of various age classes that were preyed on. Although cougar ranges often overlapped with sheep ranges, predation rates were unequal; for five collared females whose ranges overlapped with sheep ranges, 2 never killed a sheep, 1 killed one sheep and a third (F25) preyed heavily on sheep, albeit inconsistently over the study period. During winter 1993-1994, F25 alone was responsible for removing 8.7% of the early-winter sheep population and 26% of the lambs. Cougar predation has been shown to limit bighorn sheep in California (Wehausen 1996), and Ross et al. (1997) identified individual predation behavior as a disproportionate cause of sheep mortality with a strong effect on population dynamics.

Top-down predator effects vary based upon diet, abundance and individual consumption habits and rate; concordantly, the severity of ecosystem effects depend upon predator abundance and hunting range, and on preferred prey abundance and demography (Williams et al. 2004). Furthermore, localized and specialized fine-scale consumption increases impact of predation and can be regulatory. Prey switching driven by the collapse of a historically high calorie prey base of killer whales (*Orcinus orca*) is a possible proximate factor for recent sea otter (*Enhydra lutris*) and Stellar sea lion (*Eumetopias jubatus*) population declines in the Aleutian Islands (Williams et al. 2004). Models of predator energetic demands and population demography indicated that fewer than 40 killer whales could precipitate declines, and furthermore, even a pod of 5 whales could reduce sea otter populations and prevent stabilization of Stellar sea lions (Williams et al. 2004).

Intensive food habits evaluation is trending towards more complex management in assessment of functional ecological units at the population, group, and species level to include individual specialization as a potential mechanism for niche expansion and altered predator-prey dynamics. Incorporating intra-population variation in ecological research permits holistic representation of the biological community, augmenting capacity and predictive power of mechanistic population dynamics models through increased understanding of individual components and elucidating response to density dependent effects (Bolnick et al 2003).

### **Individual Genotyping**

Many hypothesized and potential applications of fecal analysis (Putnam 1984, Kohn and Wayne 1997) are being realized through contemporary research efforts. Molecular techniques applied to feces can identify species, individual, sex, parasitology, diet, and indices of physiological condition from a single collected sample (Kohn and Wayne 1997, Wasser et al.

2004). Identification of individuals through polymerase chain reaction (PCR) analysis of microsatellite loci creates a genetic fingerprint, enabling researchers to ‘tag’ members of a population and to non-invasively obtain information on kinship (Gerloff et al. 1999), population size (Kohn et al. 1999), detection of rare species over large scales (Palomares et al. 2002), habitat use, and connectivity (Beckmann 2006), assessment of non-genetic census (Guschanski et al. 2009), and determination of individual foraging habits (Reed et al. 1997).

Systematic collection and analysis of feces can lead to estimates of average food preference of a study population, but it doesn’t often include an assessment of individual variation in foraging patterns (Litvaitis 1994). Reed et al. (1997) enacted a dual approach to diet analysis, incorporating fecal analysis with genetic genotyping to assign dietary preference to individual grey seals (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*). Since then, several investigative efforts of individual diet analysis have focused on variation in coyote (*Canis latrans*) food habits and divergence from average diet.

Combining conventional fecal analysis with ‘genetic fingerprinting,’ Fedriani and Kohn (2001) compared individual diet profiles among coyotes (n = 17) in California. Analysis revealed two main groups, segregated by use of primary and secondary food sources. Furthermore, they performed simulations to assess influence of individual dietary variation on population-wide estimates of diet, potential skew of overall diet when variation is unaccounted for, and how intensively individuals need to be sampled. Results indicated diversity was significantly higher for collections re-sampling individuals three times; however, they rejected potential for small sample sizes to limit inference and ability of data to gauge diet variation.

Similarly, Prugh et al. (2008) integrated fecal analysis with genotyping to assess diet diversity and overlap among individual coyotes (n = 42) and social groups (n = 9) relative to

prey availability. Coyotes in their study area, where snowshoe hares (*Lepus americanus*) were the primary prey, exhibited low to moderate individual variation in diet. Differential patterns of hare consumption were explained by spatiotemporal variation in hare abundance; consequently, intraspecific diet variation resulted from fine scale unevenness of prey distribution. Furthermore, Prugh et al. (2008) suggested spatially structured species are more sensitive to variations in diet due to heterogeneous prey distribution owing to strong site fidelity. Certainly, this idea corroborates Ross et al. (1997) and Williams et al.'s (2004) assertion concerning disproportionate predation effects on prey populations, further emphasizing the validity of incorporating individual diet variation data in predator-prey management plans.

Both aforementioned studies suffer biases resulting from scat collection method. Fedriani and Kohn (2001) were unable to produce a representative sample to reliably assess dietary variation throughout the population, but believed they evaluated between 43% and 47% of individuals present. Additionally, sampling represented a short time interval and data did not reflect spatiotemporal variation in prey abundance and distribution, potentially eliminating presence of variation to detect. Prugh et al. (2008) surveyed during winter using backtracking and trails created by snowmobiles as primary sources of scats, unintentionally biasing observers and transect location to potentially favor a subset of the regional coyote population.

Genetic information collected in an unbiased, non-invasive method offer an appealing alternative to traditional research methods. Although error rates can be higher amplifying fecal DNA as opposed to hair, genetic material is more abundant in feces, maximizing the potential to repeat analyses (Waits and Paetkau 2005). Noninvasive collection of scats and subsequent genetic tagging incur unique problems which can introduce bias leading to erroneous results; however, current investigation and resolution of prohibitive issues (Taberlet et al. 1999,

McKelvey and Schwartz 2004, Waits and Paetkau 2005, Hansen et al. 2008) indicate an actively evolving knowledge base evident in topical literature including development of methods specific to genetic mark-recapture studies (Miller et al. 2005). Genetic tagging allows continual sampling of an individual throughout its lifetime across the range of variation encountered producing a significant portrait of individual characteristics, and a fundamental knowledge of interactions and population parameters.

Due to constraints concerning feasibility including a collecting a diverse and sufficient sample size, reliable re-sampling of individuals, and sufficient spatial coverage, the investigation of individual diet variation should be applied with a well-conceived study design and implementation strategy. Based on our literature review, it seems clear that methods relying on sporadic and opportunistic collection of samples are insufficient to overcome associated bias and limitation of statistical power.

### **Scat Detection Dogs**

Since domestication, dogs (*Canis lupus familiaris*) have served humans as companions; however, innate behaviors and odor detection capabilities have also resulted in utilization of canines for various tasks. Scent detection dogs are employed in narcotics control, search and rescue, and wildlife trafficking, capitalizing on a dog's ability to discriminate odors, seek target odors, lead handler to sources of odor, search and cover great distances, and withstand topographical and climactic challenges. Adapting their inherent odor detection ability and individual characteristics conducive to work, researchers are increasingly employing dogs in conservation research.

Particularly thorough reviews of canine selection and training are found in Smith et al. (2003), Wasser et al. (2004), and Cablk and Heaton (2006), with Mackay et al. (2007) providing

an adequate review of scat detector dog methodology background, applications, and benefits. Briefly, domestic dogs possess remarkable olfactory capabilities far outweighing humans in scent recognition and ability to perceive minute amounts or concentrations of scent (Syrotuck 2000). Candidate dogs are selected based on several criteria including strong object orientation, exhibition of work and hunt drive, and ability to air scent. Upon completion of obedience training, canines undergo a structure, methodical training regimen focusing on experiential learning in odor recognition and search strategy ultimately reinforcing routine of detection and reward. Dogs identify and locate odors at low thresholds despite presence of non-target odors (Furton and Myers 2001), learn to identify discrete sets of individuals through training, and detect new individuals in the field, regardless of sex, age, and social class (Cablak et al. 2008). They have repeatedly exhibited proficiency at locating a wide range of scents (Browne et al. 2006), and thus detection dogs trained to locate scats maximize samples collected per effort exerted in an unbiased and repeatable manner over multiple spatial and temporal scales.

Technique and handler experience, as well as environmental factors including temperature, terrain and air movements, influence efficacy of detector dogs (Syrotuck 1972). Consequently, training continues throughout the working career of a dog detection team to facilitate understanding of dog behavior upon encountering target odor, topographical influences on scent movement, and overall effectiveness of team. Continued training optimizes search time by minimizing time spent searching area to locate target samples; however, target detection ultimately reflects ability of handler and dog (Cablak et al. 2008).

Unequal probabilities of locating scats across habitat gradients and observer bias or misidentification influence data resulting from fecal analysis (Bulinski and McArthur 2000; Janecka et al. 2008). Transect placement also either intentionally or unintentionally biases data

if transects are preferentially placed for access concerns or stratified based on habitat or occupancy presumptions. Accessible habitat may contain a preponderance of roads and trails, forcing oversampling of present individuals or those frequenting linear structures within habitat. Sub-sampling or stratifying search effort to maximize data collected per unit effort while covering spatially diverse landscapes ensures certain prey or habitats may be disproportionately available for sampling and overrepresented in findings (Dairmont et al. 2008). Interactions that vary with scale, such as demographically or spatially structured predator populations interfacing with spatially variable concentrations of prey, are particularly vulnerable to such biases. These aforementioned characteristics typically accompany sampling regimes reliant upon observation and opportunistic sampling whereas detector dogs remain ubiquitous to such errors.

Conspicuous deposition site as a function of social dominance and territoriality further confounds observer bias in scat collection, potentially skewing sampling to represent a subset of the study population. Cavallinin and Volpi (1995) documented bias as a function of social status in a comparison of red fox (*Vulpes vulpes*) fecal and stomach contents where hunting and trapping were the mechanisms for carcass collection. Stomach contents represented younger and inexperienced cohorts, but fecal samples represented resident and more dominant individuals.

Use of scat dogs improves one's ability to randomly sample in the field while limiting biases associated with non-independence of samples and subsequent pseudoreplication (Hurlbert 1984) or overrepresentation of specific prey species in diet as an artifact of prey size or clumped distribution. Scat dogs survey large areas and require no baits, thus limiting biases associated with station based monitoring methods. As a result, spatially explicit parameters such as home range and habitat use are estimated more reliably.

Scat detector dogs can efficiently survey multiple species covering vast areas and recover small and cryptic scats, attributes that are beneficial when studying wide-ranging and elusive carnivores. Long et al. (2007) surveyed 74 sites throughout Vermont, targeting black bear, bobcat (*Lynx rufus*), and fisher (*Martes pennanti*) with detection dogs, camera traps, and hair snares; dogs were most effective in overall detection and unique detection rate. Estimates of detection probability assuming presence of three species ranged from a low of 8% detection of black bears with hair snares to a high of 87% with dogs. To achieve >80% probability of detection for bears, dogs need to survey a site once whereas remote cameras require 5 visits, and 20 hair snares per site are required. Besides accruing higher detection rates and more frequent unique detections, scat dogs require one visit to a study area to complete surveying.

In another comparative study of various methods in New Mexico, detector dogs produced more evidence of presence and generated 10 times the number of bobcat detections than hair snares, camera traps, and scent stations combined (Harrison 2006). Furthermore, human observers identified and collected fewer scats per transect than the poorest performing detector dog during a San Joaquin kit fox (*Vulpes macrotis mutica*) scat survey, confirming the potential of dogs to increase sample size (Smith et al. 2004). Wasser et al. (2004) reported a 71% chance of encountering new individual with each new scat located by detector dogs and collected during grid sampling, whereas detection of multiple individuals per hairs collected from a snare was unlikely.

Utilization of feces to genetically identify individuals, for discerning presence, and in estimating abundance, have compared well with traditional methods (Kohn et al. 1999, Prugh et al. 2005) and incorporating dogs qualitatively improves research (Wasser et al. 2004, Harrison 2006, Long et al. 2007). Strong correlation between telemetry derived home range boundary and

scat location of resident individuals existed for a coyote population in California (Kohn et al. 1999). Additionally, scat collected with dogs corresponded well with concurrent hair snare and GPS telemetry data during a study of brown (*Ursus arctos*) and black bears (Wasser et al. 2004). Population size estimation using fecal genotyping resulted in ‘capturing’ and identification of four times the number of individuals that capturing and radiocollaring were able to produce, and radiocollared individuals represented only 25-50% of population of study area at any time during a 3-year study of coyotes in Alaska (Prugh et al. 2005).

### **A primer concerning the process of detector dog training and field application**

Working dogs represent hours of dedication and adherence to a methodical training regimen based on obedience and repetition. Although a strong bond exists between dog and handler, these canines are not ‘domestic dogs’; rather, they embody a synergistic relationship where an adept handler ‘reads’ behavioral responses elicited by various concentrations of target odors throughout natural environments.

Dogs detect minute portions of scat, residual odors from removed scats, and scats at various levels of degradation. Dogs work in anticipation of a reward that is delivered after the handler visually verifies a scat is present where the dog indicated. If a scat is not found, no reward is given and we leave the area to continue searching. During the acclimation phase of every project initial detection/reward scenarios are critical for 'burning in' unique odors of resident target species. Reinforcement increases canine’s ability to discriminate between target and non-target odors and maximizes detection rate of target species. Conversely, few opportunities to reward the dog frustrate both handler and canine undoing detection/reward scenario therefore search effort and design are marginalized, detection prowess suffers and process of learning local target species is retarded if not halted.

Incomplete understanding of specific methodologies prior to employing them for research can marginalizing appropriate preparations and project development; this is particularly true for a novel technique such as detector dogs.

### **Selection**

Consistent with ethical viewpoint of a noninvasive sampling regime, all canine candidates are rescued from animal shelters regardless of breed, size, or age. Preferred characteristics include; an unwavering intensity and desire for a play object (tennis ball) bordering on neurosis, active disposition, unflappable pursuit of hidden play object despite presence of distraction, and ability to air scent.

### **Training Samples**

Prior to the start of training, we require an ample supply of training scats from both captive and wild sources to ensure best possible application of scat detection methodology as adequate preparation is a robust predictor of project success and the first step is collecting and preparing a quality assemblage of training samples. Dogs' olfactory capabilities are so acute and sensitive they can differentiate individuals within a species, such as humans, and differentiate between a variety of odors that appear similar to detect target scents. Natural genetic and diet variability within a species throughout its geographic range, and especially between zoo animals and wild animals, introduces confusion into training and inhibits a working dog's learning pattern.

Exposure to a high diversity of individuals and source (captive or wild) training material facilitates process of generalization allowing dog to understand variability inherent within target odor transcending potential barriers associated with individual, sex, or variable diet. Instead of relying on the feces of one or two animals to shape target odor profile we expand the breadth of

odor our detector dog is searching for. During training we want to expose canines to as much variation as possible.

It is difficult to relay the importance of the quality and quantity of training samples especially when dealing with low density target species where the opportunities for positive reinforcement in the field are rare. After the start of a project we often preserve a portion of collected samples for future use as training samples once the species is genetically identified. Whenever I am asked how many scats or individuals are enough, I predictably reply, we can never have too many training samples.

### **Training**

Training is a process and length and intensity vary upon the skill level of dog, trainer and handler. Early training sessions build a comprehensive framework when performed correctly providing a dog team with all the skills necessary to satisfactorily complete a field season. Potential hindrances are anticipated through careful observation and creative design of training problems, all the while creating a fun working environment conducive to a positive working experience. Routine and consistency are benchmarks for any effective dog training program.

### *Field Application*

Two main components, acclimation and the process of ‘burning in’, often impair successful beginnings to survey efforts, and understanding them is critical to overcoming obstacles. Acclimation is simply taking time to familiarize dogs and handlers with local terrain, weather patterns and daily rhythms. Incorporating local variations into daily routine takes time, with each passing day teams are progressing towards full scale implementation of survey; however, running training problems in habitat representative of survey area allows dog to process new odors and handlers have time to learn intricacies of behaviors which appear in this

new environment. Burn-in refers to transition from training samples to locating wild scat samples, which can take several weeks. During this time maintaining strict adherence to routine prevents dog from feeling pressure handlers invariably feel when detection rate is minimal or nonexistent thus permitting dog to learn in a natural way and predictable behavior around target odors remains intact. Availability of wild, local and 100% confirmed scat samples are integral to minimizing burn in time and bolstering confidence of handler and dog. Experienced trainers often remind handlers are responsible for 95% of the error associated with detection of non-targets through inducing 'hits' with over-suggestive behavior and inability to allow process to naturally unfold.

Development of a consistent routine of departure time, working days and day length are important components of the daily routine of a detection dog team, likewise establishing routine in sample collection during field work maintains focus of dog team throughout surveying effort ensuring sampling is repeatedly effective.

Canine detection is a process. Locating scats and receiving the reward is a fundamental component of detection work. For example, you locate 45 scats surveying 10 sites for an average of 4.5/site. If 20 additional scats are detected average scats improves to 6.5/site translating to more scats per hour, more per kilometer and, most importantly, more reward per effort expended by the dog. Thus the dog is more focused as a result of accumulated reward throughout the survey maintaining a high level of motivation for detection.

### **Factors to consider when determining number of dog teams to use**

- Target species abundance and likelihood in detecting samples. For example, bear and coyote would presumably be depositing more samples whereas lynx may be more hidden, less abundant or have more samples in one location causing a disproportionate rate of detection for

each target species. Consequently, it may not be possible to layer all the target species on each dog and separate dogs may be needed for certain species.

- Despite training efforts dogs may develop a strong affinity for one target species or avoid another, likewise a handler may develop certain biases or produce poor quality work diminishing effectiveness of team. As a precaution it is best to use at least 2 teams to compensate for bias and costs typically level out and decrease after one team is assembled (see Appendix 2 Budget).
- Depending upon the size of the study area, research goals, access and timeframe either more or less teams can be needed.

### **Training Timeline**

Typically training a dog after it is selected from a shelter and tested for ability as a working dog can take anywhere from 4-16 weeks. Training a handler can take 2-4 weeks but selection from resumes can take months. Not all handlers can complete a field season due to insufficient skills, incompatibility with project/method goals or other reasons. Likewise, dogs can be unable to complete a season due to injury therefore it is wise to have alternate plans and to constantly evaluate personnel. Following is a general timeline for training:

1. Dog selection based on selection criteria (until enough dogs are selected 1-4 weeks)
2. Begin obedience training and determine suitability of dogs for scat work (1-3 weeks)
3. Begin scat work (1-2 weeks)
4. Prior to more advanced training, trainer makes sure all dogs are suitable, if not, more selected
5. Begin more advanced training of selected dogs (1-2 weeks)
6. Start beginning training with handlers – handlers are hired temporarily to ensure compatibility with dogs, program and methodology (2 weeks)

7. Advanced field training with handlers (2 weeks)
8. Begin acclimation at field sites (1-2 weeks)
9. Start survey (1-3 months)
10. Continue training after project in preparation for future work.

## **Conclusions**

Attempting to investigate food habits at the population as well as individual scale requires not only a well-conceived study design but a sampling intensity that enables adequate exposure to a multitude of habitats and individuals at discrete time intervals. Unfortunately, this confluence of an appropriately crafted design complete with the ability to genetically analyze a sufficient sample size collected at regular intervals did not materialize during our study. In addition to fiscal, planning and manpower limitations, the formidable logistical challenges presented by the sheer size, remoteness and ruggedness of Newfoundland proved too massive an obstacle to overcome. However, we did accumulate a wealth of information that informed our effort on a seasonal and yearly basis which served to improve our surveying efforts for the four years we participated in the study.

Our canines were highly effective at both navigating the landscape and discovering target samples in ample quantity with great accuracy. During two field seasons from the start of June through August in 2009 and 2010 we collected over 909 samples from black bear (N = 392), coyote (N = 414), gray wolf/dog (N = 2), lynx (N = 26), and red fox (N = 75). Once a sample was located by one of our detector dogs, the handler recorded their confidence in the 'hit', the dog's response, and the putative identification of the sample, as well as a digital data form detailing the scat location and environmental conditions. For black bear, our putative identification, in essence the reliability of the dog's effort, was correct on 95% of the samples

from 2009 and 97% from 2010. We fared a little worse with coyote, and were accurate 91% of the time over both years. Based on our high rate of success in identifying our target species in the field, we included samples in the analysis which did not successfully amplify (no genetic species identification) to increase our sample size.

Each detection dog was assessed throughout the field season to ensure a bias towards any target species or non-target species did not develop. Recurrent positive reinforcement exercises were performed with the inclusion of local, native Newfoundland target species scat samples. Individual dog performance was summarized under Canine 1 and Canine 2. Both Canine 1 and Canine 2 found a greater percentage of their total samples in 2010 (Table 1.1). While Canine 1 found more coyote samples in 2009 and more bear in 2010, Canine 2 remained consistently a stronger performer with bear than coyote (Table 1.2).

Likelihood of locating a sample without a canine was assessed for each scat. This was designed to gauge not only how likely you were to deviate from your current path of travel to the scat location but how challenging the sample was to see. For example, if you were walking off trail and randomly traveling through some low shrub habitat, if you would have traveled into the scat location on your own and would have been able to find the scat, it was given a value of high. Most often, the sample was still visually difficult to locate once the dog indicated its' presence due to the lack of color contrast and dense understory vegetation. Out of 214 samples we estimated that 77% were impossible to find due to the high likelihood they were in either grass or vegetation (Table 1.3). We tested this on a road we typically found coyote scats on with three different detection methods; driving slowly and observing from the vehicle, walking slowly down the middle at a consistent pace (similar to working with dog) and with the canine. We stopped after two trials as with the vehicle we found 10% (3 of 29) of the scats, walking we

found 24% (7 of 29) and with the dogs we found 97% (28 of 29). While surveying, we did find scats on roads (Table 1.4) and based on our simple trial and anecdotal evidence, we felt justified in using the dogs to increase our overall effectiveness.

Overall, our research effort greatly benefited by the use of specially trained detector dogs. The challenging landscape, patchy pattern of predator, and subsequently, scat location, and need to sample multiple individuals over multiple scales all necessitated a unique approach to sample procurement. By combining our skill in dog training and genetic analysis we were able to confidently increase our sample size, and the breadth of our analysis.

Table 1.1. Breakdown of individual canine sample capture as a percentage of all genetically confirmed samples collected by Canine 1 (N = 332) and Canine 2 (N = 324) in 2009 (N = 264) and 2010 (N = 392).

	Canine 1	Canine 2
2009	42	38
Bear	41	61
Coyote	59	39
2010	58	62
Bear	53	63
Coyote	47	37

Table 1.2. Breakdown of genetically confirmed black bear (N = 361) and coyote (N = 295) by year and by canine.

	Bear	Coyote
2009	37	44
Canine 1	44	63
Canine 2	56	37
2010	63	56
Canine 1	44	55
Canine 2	56	45

Table 1.3. Likelihood of locating the sample (%) without the canine was recorded as well as whether or not the scat was concealed and what type of concealment was visible (n = 214).

	Impossible (77)	Low (13)	Medium (10)	High (1)
Not Concealed	1	0	10	50
On mound	1	0	100	100
Conceal Type	99	100	90	50
Buried	2	0	0	0
In grass/Veg	90	81	68	0
Leaf litter	0	4	0	0
On mound	8	15	32	100

Table 1.4. Samples collected along roads for each species (black bear, N = 84 and coyote, N = 116) categorized based on road type and width with percentages of samples.

Road Type	Bear (42)	Coyote (58)
ATV/access	14	33
<1 meter	42	13
1 m - 2.5 m	58	87
Main dirt	20	23
>2.5 m	24	0
1 m - 2.5 m	76	100
Main paved	0	1
> 2.5 m	0	100
Secondary/pr	62	36
>2.5 m	4	5
1 m - 2.5 m	96	95
Wildlife trail	4	7
<1 meter	100	88
1 m - 2.5 m	0	13

## CHAPTER 2

# TROPHIC RELATIONSHIPS AMONG CARIBOU CALF PREDATORS IN NEWFOUNDLAND

### **Abstract**

We investigated black bear (*Ursus americanus*) and coyote (*Canis latrans*) food habits in three study areas throughout Newfoundland, Canada, using specially trained scat detection dogs and microscopic hair analysis. Sampling effort was organized spatially with grids and temporally by seasons which signified important resource use transitions for woodland caribou (*Rangifer tarandus caribou*) and their calves. Black bear diet was characterized by high frequency of grass, ants, caribou and moose during all sampling periods (year, study area, ecological season and inside/outside calving ground). Mammalian prey, caribou, moose and snowshoe hare, characterized the diet of coyotes. Analysis revealed that both species had a high frequency of occurrence of caribou calves inside the calving grounds but the frequency of occurrence per food type was low for both species. This suggests caribou calves are a component of both predators diets however, our data does not suggest the episodic availability and vulnerability of calves represents an integral component of the predators diet.

### **Introduction**

Throughout North America woodland caribou (*Rangifer tarandus caribou*) are listed as threatened or endangered with the exception of insular Newfoundland. Populations in Newfoundland were depressed for much of the 20th century, and despite management efforts caribou were rare until an exponential increase that peaked in the mid-1990s at approximately

100,000 caribou; since then, caribou populations have precipitously declined. Predictably, demographic and morphological indices associated with herd structure are representative of the deteriorating conditions. Age structure as a consequence of declining recruitment reflects an overall advanced age, and fewer males are present, skewing the sex ratio; as a result, these negative effects further compromise reproductive potential within herds. Also, body size characteristics, such as female jawbone size, male antler size and birth weight, have declined significantly island-wide (Mahoney and Weir 2007). Despite these demographic and morphological indices suggesting nutritional stress or other density dependent factors as causes for the decline, poor calf survival, largely due to predation by black bears (*Ursus americanus*), coyotes (*Canis latrans*), and lynx (*Lynx canadensis*), seems to be a major proximate cause identified by current research (Mahoney and Weir 2007).

Historical reviews (Bergerud 1971, Bergerud 1974, Meldgaard 1986, Messier et al. 1988) detail episodic and dramatic population cycles. Causal factors are stochastic and vary regionally; notwithstanding, population regulatory mechanisms are hypothesized to be either habitat- or predation-based (Bergerud 1980, Couturier et al. 1990, Seip 1992). Throughout their range caribou spatially segregate themselves from moose (*Alces alces*) and other ungulates as an anti-predator tactic; however, the presence of alternate prey species often increases caribou mortality (Bergerud 1974, Seip 1991, Wittmer et al. 2005). Furthermore, human development and associated demographic and movement effects predispose caribou to predation (Mahoney and Schaefer 2002, Mahoney and Virgl 2003, Weir et al. 2007). Additionally, habitat deterioration and hardship causing poor maternal health can result in decreased neonate birth weight and nutrition, and unfavorable calving ground characteristics increase vulnerability to predation (Skogland 1984, Mahoney and Virgl 2003, Gustine et al. 2006).

Major causes of caribou calf mortality include hypothermia, desertion, birth defects, starvation, disease and predation; however, predation is typically the main agent of mortality (Bergerud 1971, Mahoney et al. 1990, Seip 1992). Predation risk is highest during the first 12 weeks of life and over 40 years ago lynx predation was implicated by Bergerud (1971) as the proximate cause of calf mortality in Newfoundland. However, Mahoney et al. (1990) noted black bear predation was not emphasized by Bergerud (1971), yet they reported bear (35%) and lynx (35%) were equally responsible for mortality (total by predation 78%) during a 5-year calf study. Despite this prognosis, predation pressure alone is unable to decrease herd size provided adequate calf survival and recruitment (Mahoney et al. 1990); however, current conditions indicate calf survival has dropped from 63% (1979-1997) to ~1% (2003-2005) (Mahoney and Weir 2007). Predation primarily by black bear, coyote, lynx and bald eagle (*Haliaeetus leucocephalus*) accounted for 112 of 142 collared calves deaths (83%); consequently, coyote and eagle predation could be additive as previous studies failed to identify them as important calf predators (Mahoney and Weir 1990). Throughout the woodland caribou's North American range, wolf (*Canis lupus*) predation is known to limit the ungulate's population size (Seip 1991) and little is known concerning the regulatory function of alternate predators. In multiple predator-multiple prey systems, efforts to predict consequences in changes in numbers of any of the involved species are speculative, at best (National Research Council 1997).

Predation on caribou calves is related not only to the relative abundance and distribution of calves, but also to alternative food sources used year-round by the various predators. When alternate prey species are able to support a higher population of predators than would be supported by caribou alone, the potential effects of predation on caribou are increased (Seip 1992, Rettie and Messier 2000). Therefore, an understanding of predator food habits, trophic

relationships among sympatric predators, and the role that alternate prey play in sustaining predator numbers is essential to understanding calf predation.

In order to investigate trophic relationship among sympatric carnivores across insular Newfoundland (black bears, coyotes, and lynx) we investigated species-specific food habits throughout three study areas in Newfoundland by using specially trained scat detection dogs to systematically survey for scats. Objectives of research effort are to (1) locate, collect, and analyze fecal samples with sufficient temporal and spatial diversity to assess area-, species-, seasonal-, and individual-specific food habits, and (2) use scat locations in conjunction with and in comparison to telemetry spatial information collected by others to assess habitat use (relative to diet component distribution, etc.), in order to better understand rates of caribou calf predation.

### **Study areas**

Predator food habits were studied in 3 areas in insular Newfoundland delineated by the Caribou Management Areas associated with the La Poile (LP), Middle Ridge (MR), and Northern Peninsula (NP) caribou herds (Figure 2.1). Unless noted, all study area descriptions are adapted exclusively from Damman (1983).

The LP study area is 11,252 km<sup>2</sup>, and encompasses 4 ecoregions. In the Western Newfoundland Ecoregion, located below the Long Range Mountains on the western periphery of the study area, balsam fir (*Abies balsamea*) forests are interspersed with mountain maple (*Acer spicatum*) and speckled alder (*Alnus rugosa*) thickets, alder (*Alnus* spp.) swamps, and large areas of peatlands in flat terrain. Yellow birch (*Betula lutea*), eastern white pine (*Pinus strobus*), red maple (*Acer rubrum*), and quaking aspen (*Populus tremuloides*) are found in the forested areas. This ecoregion experiences the longest growing season on the island, in part due to a wet climate. The Long Range Barrens Ecoregion makes up most of the study area, and here the

prevailing habitat is comprised of open tundra with sheep laurel (*Kalmia angustifolia*) dwarf shrub heaths, peatlands, and black spruce (*Picea mariana*) coniferous shrub thickets less than 1 meter in height. Stunted tamarack trees (*Larix laricina*) are also frequent, as are many arctic-alpine species. The northeastern corner of the study area is located in the Central Newfoundland Ecoregion, which includes the Annieopsquotch Mountains, where elevations can reach 677 m. Dense forests of balsam fir and steep slopes with summits above treeline characterize this region. The eastern and southern perimeter of the study area is located in the Maritime Barrens Ecoregion. Elevations here rarely exceed 300 m. Extensive barrens of dwarf shrub heaths, bogs and shallow fens characterize this region, and fires are a frequent component of the ecosystem. Sheep laurel dominates the dwarf shrub heath, and rhodora (*Rhododendron canadense*) and lowbush blueberry (*Vaccinium angustifolium*) are plentiful. Balsam fir forests line the valleys, single trees or patches of stunted tamarack are found in the open barrens, and speckled alder thickets are found in riparian areas. This ecoregion experiences cold summers, mild winters, and frequent fog and precipitation. The median number of days with snow cover of at least 2.5 cm ranges from 90 days in the south to about 150 days in the north (Potter 1965). Most of the study area is roadless. The human population living within the study area is constrained to the perimeter and was estimated at 5,240 individuals in the 2001 census (Statistics Canada 2001).

The MR study area is 13,370 km<sup>2</sup>, and encompasses 2 ecoregions. Most of the study area is located within the Maritime Barrens Ecoregion (see the LP study area description above for details). The northeastern corner of the study area is in the Central Newfoundland Ecoregion, and is comprised of black spruce and balsam fir forests, and sheep laurel dwarf shrub heaths. Mountain maple thickets and speckled alder swamps also occur. The growing season varies from 140-160 days. The median number of days with at least 2.5 cm of snow cover ranges from

90 days in the south to about 150 days in the north (Potter 1965). Most of the study area is roadless. The human population living within the study area is constrained to the perimeter and was estimated at 1,837 individuals in the 2001 census (Statistics Canada 2001).

The NP study area is 5,711 km<sup>2</sup>, and encompasses two ecoregions. The Northern Peninsula Forest Ecoregion surrounds the Long Range Mountains, which reach elevations of 450 m, and run north-south through the study area. Dominant cover is coniferous forest comprised of balsam fir and black spruce. White spruce (*Picea glauca*) and paper birch (*Betula papyrifera*) are also common in the forest canopy. Mountain alder (*Alnus crispa*) and willow (*Salix* spp.) shrub thickets occur frequently, and mountain maple, red osier dogwood (*Cornus stolonifera*), and speckled alder thickets occur occasionally. The Long Range Barrens Ecoregion is open tundra habitat comprised of sheep laurel dwarf shrub heaths, peatlands, and black spruce coniferous shrub thickets less than 1 meter in height. Stunted tamarack trees are also frequent, as are many arctic-alpine species and snow bank vegetation. The median number of days with snow cover of at least 2.5 cm ranges from 150 days in the south to 180 days in the north (Potter 1965). The growing season is restricted to 110-150 days along a north-south gradient. Active forest management has created an extensive road system throughout the study area. The human population living within the study area is constrained to the perimeter and was estimated as 6,627 individuals in the 2001 census (Statistics Canada 2001).

Woodland caribou herds occupy discrete areas within Newfoundland and are spatially separated throughout the island. The three study areas represent distinct habitats within Newfoundland and achieve our goal of spatial diversity as they cover differing regions of the island.

## **Methods**

### **Survey design**

Our first sampling effort (May through July 2009) focused on establishing search strategy and adapting training techniques to optimize performance in the field. Differing sampling regimens were applied to determine effectiveness where, upon completion of season preliminary data analysis, results were applied in a manner to test and adapt my approach. Initial surveying is important to determine long-term design and assess feasibility of various search strategies and to design a statistical model or approach and identify constraints in surveying and implications on statistical integrity. Additionally, this sampling period provided fecal material for genetic analysis and comparison with tissue materials collected during trapping efforts to assess feasibility of in-depth molecular analysis.

During the calving (1 – 27 June) and summer season (28 June – 31 August) in 2009 and 2010, we collected black bear, coyote and other carnivore scat by randomly searching assigned grids in three study areas in Newfoundland, Canada, on a daily basis (Figure 2.1). To spatially segregate our effort we overlaid the study area with 12 x 12 km grids in the LaPoile (Figure 2.2), Middle Ridge (Figure 2.3) and Northern Peninsula (Figure 2.4) study areas which incorporated known caribou calving regions and surrounding habitat. We temporally segregated effort by repeating each grid at on a rotating schedule of 2 to 3 weeks depending on access, weather and other surveying conditions. To focus our research efforts on identifying any specialized predator activity relating to caribou calves we chose to adopt ecological seasons based on caribou life history characteristics identified by Rayl et al (2014). With this in mind, our sampling regimen was designed to provide equal sampling opportunities during ecological seasons (calving 1 – 27

June and summer 28 – 31 August) and within and without the calving grounds (Rayl et al 2014). Surveying was considered complete once all grids were sampled during each session.

Searches were performed with a specially trained handler and scat detection dog in areas accessible by helicopter or vehicle. Typically, for surveys at sites accessed by vehicle we began and ended at the same location (parking location) while the sites accessed by helicopter had distinct drop off and pick up locations. While searching the handler would guide the dog away from potential hazards and attempt to walk in a loop using the wind to increase scent detection. This was the only clear direction given by the handler as this methodology works best when the canine has the freedom to search the environment with as little restriction as possible to increase the exposure to unique scents and opportunities for sample procurement and positive reinforcement.

### **Sample collection**

Once located, scat sample location was recorded, a data sheet was completed and each sample was stored in a Ziploc bag with a unique identification code (log number). Additionally, a 1-2 ml portion of each sample was placed in a vial for genetic analysis and the remaining portion stored for our diet analysis. Diet samples were stored in a freezer.

### **Prior to analysis**

Unfortunately, we were unable to reliably identify any of our hair samples without microscopic means. In particular, we were unable to distinguish ungulates and neonates from each other. We focused on both primary and secondary hair types and worked on identifying them macro- and microscopically. We made slides from each species representing a diversity of hair types (guard hair and underfur), body locations and seasonal variations when applicable and either photographed images or wrote detailed text descriptions. We also had samples from

caribou representing a diversity of age classes (calf, yearling, adult) as the hair of calves/young is often dissimilar from adults of the same species to ensure we could reliably distinguish calves from other age classes.

We developed a hair sample reference collection from three primary sources; hair collected from carcasses during field surveying in Newfoundland, hairs collected from natural history collections from Newfoundland and hairs from the University of Massachusetts Biology Department Natural History Collection. Mammalian remains were classified to species primarily based on hair identification and tooth or bone identification when possible. We also identified age class as calf or adult for caribou and moose when possible based on our ability to observe differences in scale patterns. This process involved more time and detail than simply identifying remains to order, family or species.

Virtually every published manuscript follows a different methodological approach in preparation and use different chemicals for cleaning and adhesion of hairs. However, making quality slides which detail the characteristics of the medulla and cuticle scale patterns takes time and is important in efficient and effective identification. Therefore our first step was to ensure we could identify species from our reference collection. During this process we vetted cleansing and adhesive agents as the literature is replete with choices. After a process of trial and error we rejected several cleansers and adhesives and found CVS brand regular nail polish remover to be the best hair cleanser and Duco Cement multipurpose household glue to be a superior product when creating cuticular scale impressions for the species present in our study area.

Initially, we attempted to employ a point-frame method which proved to be time consuming and did not gain any analytical advantage (Ciucci et al. 2004). Additionally, each scat was so variable in terms of dry mass we could not come up with a standard grid size that

was appropriate for all scats. We maximized our effort to taking a sub sample based on two criteria: (1) potential to be a primary or secondary guard hair from a single species, and (2) length. We also experimented with the number of hairs per sample to test and began with 20/scat which took considerable effort and did not incur an analytical advantage over selecting fewer hairs which permitted us to prepare and analyze more samples in less time.

### **Diet analysis**

Scats were thawed in individually labeled pie tins and carefully washed. We used either a 0.25 mm (U.S.A. Standard Test Sieve) or 0.85 mm sieve (Canadian Standard Sieve Series) to mechanically remove the fecal material from the hard part (hair, bones, seeds) remains of samples. Care was taken to preserve as much hair, bone and other remains in each sample. Samples were dried in a gravity convection oven and placed in a brown sandwich bag marked with the log number and stored in waterproof containers for analysis.

Prior to selecting hairs for identification, indigestible materials such as bone, teeth, seeds and insect exoskeletons were separated from the sample and placed in 1" x 2" coin envelopes labeled with the sample log number. Teeth, jaw, arm and leg bones were particularly useful in identifying species and age (growth discs on the humerus indicated a juvenile snowshoe hare). Additionally, we would find partially intact hare phalanges with nails or Cervid hoof tips.

Each sample was sorted on a white, enamel lab tray and organized into distinct categories based on type of guard hair (primary or secondary hair), underfur and by length. This was a means to estimate what we envisioned to be a prey item and a group we needed to identify (sorting and labeling approx. 12 mins/sample). The most representative hairs from each group were selected in proportion to groups identified. For example, if we identified three potential groups, or three prey items present, approximately a third of the hairs selected were from each

group which consisted of guard hairs and underfur. Selected hairs were placed on a white sheet of paper which was folded into a coin envelope marked with the log number. Typically, 9 – 12 hairs were selected from each sample.

All selected guard hairs were soaked briefly in a plastic lab cup with nail polish remover to remove any residual fecal material or oil from the hair. All the hairs were removed and placed in a Kim wipe which was folded over to prevent loss of hairs to allow hairs to dry completely. Standard microscope slides were labeled with the log number and approximately 4 or 5 thin beads of Duco Cement were applied horizontally on the slide. After applying the cement, we carefully placed the hairs from the Kim wipe into the cement on the slide. Care was taken to make sure the hairs did not overlap and glue did not stick to the forceps. The glue took approximately 15 minutes to dry and a sewing needle and forceps were used to remove the hairs. When possible the distal portion of a hair sample was not placed in the glue to facilitate removal of the hair to expose the scale pattern. Species were identified using compound microscopes to observe the corresponding cuticular scale pattern. Reference collections such as Kennedy and Carbyn (1981) were used as well as our own diagnostic method.

When we calculated the number of prey items an average sample contained without wood as a unique food item over 70% of the bear samples had 2 or fewer items (Table 2.3). In 110 of 133 (89%) samples with wood, ants were also present. For coyote samples, 48% were composed of one prey item and 36% of two; therefore only 16% of the samples contained 3 or more prey items (Table 2.4).

We employed a simple binomial structure in recording prey presence: a 1 was assigned when a specific prey item was present, and a 0 if absent. We expressed our results as: frequency of occurrence per scat (calculated as the number of times a food item occurs/total number of

scats in that sampling session X 100) and frequency of occurrence per food item (calculated as the number of times a food item occurs/total number of occurrences of all food items X 100).

Mammalian prey items were identified to species. Mammalian prey identified in predator remains include beaver (*Castor canadensis*), caribou (*Rangifer tarandus caribou*), meadow vole (*Microtus pennsylvanicus*), moose (*Alces alces*), southern red backed vole (*Myodis gapperi*), red squirrel (*Tamiasciurus hudsonicus*), and snowshoe hare (*Lepus americanus*), representing 7 of the 27 mammal species present on the island (Table 2.5). When possible, Cervid and Lagomorph remains were identified by age class; adult, calf or juvenile. To simplify identification insect remains were grouped as ants or beetles while plant remains were grouped as grass, mast, needles, seeds or wood.

### **Individual diet**

All tables were calculated to permit a comparison between the frequency of prey items per scat for the original, intact sample (All) and the sample (Without) after genetically identified samples from a specific individual were removed (Individual). By re-calculating the frequency we can compare All to Without and see if the removal of individuals has an effect on the frequency of items. Of course this can be attributed to a change in sample size but some sampling periods remained over 30 samples even after the reduction by removal of individuals. In order for us to calculate the frequency of an individual as distinct from the sample we required a minimum of three collected samples per sampling period.

## **Results**

We collected a total of 393 black bear scats and 414 coyote scats (Table 2.1 and 2.2). Four mammalian species (beaver, caribou adult and calf, moose adult and calf, and snowshoe hare), 2 arthropod groups (ants and beetles) and 5 plant groups (grass, mast, needle, seeds, and wood) were identified in bear scats. A total of 6 mammalian species (beaver, caribou adult and calf, moose adult and calf, red back vole, red squirrel, and snowshoe hare adult and juvenile), one arthropod group (ants) and two plant group (grass, seeds) were identified in coyote scats. Our remaining results are presented as percent frequency occurrence per scat and food item frequency of occurrence to facilitate comparisons across sampling sessions with highly variable sample sizes.

Throughout all study areas, years, ecological seasons and inside and outside the calving grounds, caribou, moose, ants, grass and wood were most frequently observed in bear scats (Table 2.6). A seasonal shift in Cervid and ant consumption was observed in every sampling strata as the frequency of Cervid remains decreases as ants increase during the transition from the calving to summer season. Frequency per food item for bears support this shift and reveal the overall importance of ants and grasses in the composition of the bear diet (Table 2.7.).

Coyote diet was dominated by caribou, moose and snowshoe hare in all study areas, years, ecological seasons and within and outside the calving grounds (Table 2.8). A shift in prey frequency was evident in coyote samples whether a sample was located inside or outside the calving ground. Overall, caribou was found more frequently inside the calving ground (6 of 7 sampling strata) and moose (5 of 7) and snowshoe hare (5 of 7) more frequently outside the calving ground. However, we accumulated very low sample sizes inside the calving ground in both LaPoile and the Northern Peninsula in 2009. Diet composition data reflect this seasonal

trend as well and highlight the importance of the mammalian prey for coyotes during all seasons (Table 2.9).

### **LaPoile**

While ants (58%) and grass (79%) were most frequently found in bear scats in LaPoile during the calving season, ants (91%) became the dominant food by frequency during the summer season (Table 2.9). This is also evident with the coyote samples as adult moose are found in 78% of scats during calving and in 47% during the summer season (Table 2.22). The frequency of caribou (43 to 46%), caribou calf (22 – 21%), and snowshoe hare (48 – 45%) stayed constant outside the calving area in both seasons.

### **Middle Ridge**

Locational variation in prey items in bear samples was evident during the summer season as caribou (48%) and moose (16%) was more frequently observed inside the calving ground than outside (33% and 7% respectively) (Table 2.11). Conversely, ants increased from inside (68%) to outside (83%) the calving ground. Snowshoe hare was present both inside (32%) and outside (20%) the calving ground. Interestingly, by composition inside and outside, snowshoe hare represent 12 % and 7% of bear prey items while caribou calves represent 6% and 2% (Table 2.7).

A similar shift in diet based on location was evident with coyote. Both caribou (52%) and moose (26%) was more frequent inside the calving ground than outside (36% and 19% respectively) (Table 2.23). Snowshoe hare was represented in an opposite frequency as they occurred in 50% of samples inside and 80% outside. Grass was present in 55% of the samples located inside the calving ground. This was by far the highest representation for coyote and could be attributed to habitat differences.

## **Northern Peninsula**

Caribou adult was found more frequently in bear samples located outside the calving ground in the Northern Peninsula, and caribou calf frequency of occurrence was highest inside the calving ground during two sampling periods and outside during two other (Table 2.11). Moose were always more frequent in scat samples located outside the calving area and snowshoe hare was detected both inside and outside the calving ground in 2010 albeit at a low frequency. The occurrence of ants demonstrated a marked trend towards being more frequent outside the calving grounds in every sampling strata.

In three of four seasons over two years (calving 2009, calving 2010, summer 2010), caribou were more frequently occurring in scats located within the calving ground, while caribou calves were always more frequent in coyote scats inside the calving area when present (Table 2.24). Moose demonstrated the opposite trend and were more frequent in samples located outside (calving 2009, summer 2009 and 2010) rather than inside the calving grounds in 3 of 4 sampling seasons.

Between 2009 and 2010 variation was also evident during the summer season outside the Northern Peninsula calving ground. Moose decreased from 51% to 37% and snowshoe hare decreased from 74% to 49% (table 2.28).

### **Comparison inside calving grounds**

When we examine only bear scats inside the Northern Peninsula calving area during the calving season, although there is a small sample size for both years (2009, n = 14 and 2010, n = 11), there is a decrease in caribou frequency (43% to 23%) from 2009 to 2010 and an increase in moose from 29% to 52% (Table 2.13). Grass and ants match this trend, as grass decreases with caribou frequency and ants increase with moose. During the summer season both caribou and

moose frequencies were similar and relatively unchanging for the Middle Ridge (2010) and Northern Peninsula (2009 and 2010) study areas but they are less frequent when compared to the calving season (Table 2.15). However, in the Middle Ridge caribou were far more frequent (48%) and this area also saw the highest frequency of caribou calves (16%).

Coyote samples collected from inside the calving ground during the calving season reflected an overall low sample size from three sampling strata; however, caribou occurred most frequently (Table 2.25). During the summer season the data from 2009 represented only 5 samples from 2 study areas. In 2010 during the summer season, caribou (52 and 64%) and snowshoe hare (50 and 61%) were more frequent in both study areas, the Middle Ridge and Northern Peninsula, than moose (26 and 21%).

### **Comparison outside calving grounds**

Samples from bear collected outside the calving ground during the calving season from the Northern Peninsula in both 2009 (67%) and 2010 (51%) indicated a higher frequency of caribou were present when compared to the LaPoile (17%) study area (Table 2.14). Moose were also more frequent in the Northern Peninsula; however, ants were more frequent in LaPoile (91%) compared to the Northern Peninsula in 2009 (33%) and 2010 (85%).

During the summer season black bear samples demonstrated a study area difference in moose and ant frequency and a yearly shift in grass frequency (Table 2.18). Both Northern Peninsula samples (2009 and 2010) had a higher frequency of moose (52 and 24%) compared to LaPoile (22%) and the Middle Ridge (7%) which corresponded with a lower frequency of ants (65 and 59%). Grass frequency increased from 2009 to 2010 across study areas, from 39% (LaPoile) and 42% (Northern Peninsula) to 70% (Middle Ridge) and 78% (Northern Peninsula).

Caribou frequency during the calving season in coyote samples from outside the LaPoile (43%, 2009) and Northern Peninsula (57%, 2010) calving grounds were higher than in 2009 (29%) for the Northern Peninsula (Table 2.26). These samples, which showed a lower frequency of moose (36%) as well, showed a higher occurrence of snowshoe hare (71%) compared to the sampling periods with higher caribou frequency.

### **Individual Diet**

Genetic analysis identified 71 unique black bears and 79 coyotes from samples during the project (Table 2.17 and Table 2.29). Unique individuals were genetically identified in all but one sampling session for bear (11 out of 12) and in all sessions for coyote (14 out of 14).

This analysis is predicated on the successful genetic identification of individuals; consequently, for black bear, we are restricted to the Northern Peninsula study area. During the calving season inside the calving ground, Individual 41 ( $n = 3$ ) was identified and caribou was detected at a higher frequency for this individual and ants were not found at all (Table 2.18). Two individuals were recognized inside the calving ground during the summer seasons of 2009 ( $n = 46$ ) and 2010 ( $n = 65$ ). In 2009, moose (17 to 22%) and ant (54 to 64%) frequency increased when Individual 40 and 43, both of whom had no moose present in their diet, were not included in the analysis. In 2010, caribou calf was not detected in the samples from Individual 96 and 251, yet All and Without had a frequency of 5%.

### *Caribou calves*

For black bears, caribou calves were identified in 9 of 12 sampling strata and with the exception of sampling during the summer of 2009 and calving season of 2010 in the Northern Peninsula, frequency of occurrence was highest within the calving grounds (Table 2.6). From a

compositional standpoint, caribou calves, when present, represented 2 – 8% of the prey items identified (Table 2.7).

In black bear scats located in the Northern Peninsula study area during the calving season, caribou calf frequency decreased inside the calving ground from 2009 (14%) to 2010 (6%). However, outside the calving ground during the calving season, the frequency of caribou calves increased from 0 to 19% over years but this may be a function of the small sample size from 2009 (n = 3).

Caribou calves were detected in 9 of 12 sampling strata and with the exception of the LaPoile in 2009 during the calving season were found with a higher frequency inside the calving grounds (Table 2.8). When identified, caribou calf remains were found in 13 to 50% of the samples. When analyzing the coyote diet on a per food item basis, caribou calves represent 7 – 50% of all prey items found in 9 of 12 sampling strata indicating they can be a potentially important food item for coyote (Table 2.9).

When comparing coyote samples, we only saw two incidences of a higher frequency of caribou calves than caribou adults, both occurred in the Northern Peninsula (Table 2.24); samples collected outside the calving ground during the summer season in 2009 (23% to 18%) and inside the calving ground during the calving season in 2010 (44% to 28%). In 2010 during the summer season, caribou calves were still present inside and outside both the Middle Ridge (19%) and Northern Peninsula (32%) calving grounds (Table 2.27 and 2.28).

## **Discussion**

Dietary shifts are commonly seen for bear (Roof 1997) and coyote (Witmer et al. 1995) based on timing and sequence of plant availability, fruiting and other episodic food items. Our results indicate bear are more omnivorous while coyote rely on mammalian prey during the

calving and summer season in Newfoundland. Ants and grasses were more frequent in bear scats than caribou and moose remains and were more frequent per food item than mammalian food items. This suggests that non-mammalian prey is of importance to bear. These results are consistent with other findings indicating bear rely on vegetation (Day 1997). The frequency of mammalian prey in our study area in the early season was higher than the reported values in Quebec; however, ants were observed with a high frequency in both areas (Bouleau et al. 1994). Interestingly, ants appear to be sensitive to sample size as strata with under 20 samples had low frequencies (7, 18 and 33%); however those over 20 samples were over 43% (43 – 91%, average 64%). Caribou was more frequently identified in coyote scats inside the calving grounds and moose and snowshoe hare were more frequent outside, with the exception of the sampling periods with low sample sizes. This observation supports the idea that coyotes are opportunistic feeders and perhaps the addition of non-native species benefits coyotes and their ability to take advantage of their environment.

When considering the benefits of volumetric analysis we noticed the high incidence of wood in bear scats was likely a result of accidental consumption while targeting ants. Therefore, we felt this correlation justified removing wood from this calculation. Attempts to estimate the volume of items per scat failed for several reasons. First, samples were highly variable in initial volume due to decomposition in the field and loss of material while washing (ant parts, fine hairs). Secondly, grouping of prey items based on visual inspection proved too difficult to reliably repeat as the quantity of guard hairs was typically low in samples and we were not confident in grouping underfur. Considering these factors as well as data which indicated most samples contained fewer than 2 prey items, volumetric measurements seemed unreliable and

unnecessary. Finally, our objective was to determine the presence and absence of prey items not to assess the energetic value

To assess whether or not the trends we observed impacted the overall diet of a predator, we calculated percent occurrence by food type. This qualitative analysis allowed us to identify food items which may represent specialized behavior (Kluare et al. 2011). While caribou calves were observed in all but one coyote sampling session within the calving grounds, the frequency of occurrence was typically higher than the occurrence per food item. This suggests that calf remains were not an important prey item in the overall diet for coyote as occurrence per food item identifies items seen most frequently seen in the overall diet. Calves were absent from two sampling periods within the calving grounds for bear scats, however the frequency of occurrence was higher than for coyote. Unlike coyote frequency per food item, calf composition for bears suggests a more meaningful contribution for bear diet.

Previous research indicated that either black bear (Mahoney et al. 1990) or coyote (Fournier and Faubert 2001) or both (Crete and Desrosiers 1995) can target caribou calves and limit recruitment. While we did observe calf remains during our sampling, several reasons may have limited our ability to accurately assess calf predation. First, a diet high in meat can induce diarrhea in the predator thus locating those scats can be difficult to locate and identify items within. On several occasion we found kill sites of either caribou adults or calves or moose and several scats at each location were impossible to collect. We also found this while working on wolves in northern Alberta at kill sites. Second, the pulse of caribou calves can be sensitive to weather, habitat and maternal conditions that are difficult to predict. Due to the unpredictable nature of the environmental conditions in the study areas, particularly during calving, often limited our ability to access sites, particularly sites accessible by helicopter, due to weather. An

additional consequence of the time sensitive availability of calves is how quickly the remains are consumed by either the predator responsible for the kill or the scavenging of remains.

Comparing across year, study area and season can be difficult due to contrasting sample sizes. When sample size is highly variable differences in diet can be due to detection rates and overall number of prey items present rather than an actual shift in dietary patterns. However, the prey diversity remained constant throughout the study permitting us to make comparisons as our confidence in accurate sampling remained consistent (Klare et al, 2011). Recommendations in the literature detailing an appropriate sample size per sampling session to ensure accurate reporting encompass two main ideas; the breadth of the predator's diet and the seasons incorporated into sampling. Generally, you need more samples as the complexity, in terms of total number of prey taken, increases to ensure accurate sampling. We found the diets in Newfoundland of our target species, black bear and coyote, to be rather simple and incorporating few species over all seasons sampled.

To focus our research efforts on identifying any specialized predator activity relating to caribou we chose to define our ecological seasons in terms of caribou life history characteristics, specifically the calving period. Based on space-use models which identified clusters of activity, four caribou specific seasons were identified by Rayl et al (2014). While our attempt to stratify sampling in many discrete categories was ambitious, our sample size per strata was oftentimes insufficient for complex analysis. Combined with the limited breadth of food items consumed by our target species, we lacked confidence in our ability to prove relationships with statistics. However, we are confident that our choice of method gave us the best opportunity to randomly collect a representative sample from a diversity of locations. Additionally we felt pooling samples across strata, while improving our sample size, would negate the purpose of the analysis

which would be to identify a dietary shift or difference between and among years, study areas, seasons and locations (inside and outside calving grounds). Consequently, we felt the use of frequency of occurrence, although simplistic, is an effective way to generally describe diet while allowing for comparisons between and within years, study areas, and seasons.

The use of canines to identify target samples provided many benefits, oftentimes target samples are incorrectly identified by observers (Davison et al. 2002), only high confidence samples are collected based on known diet or size (Cepak 2004), and collection is limited to areas observable by humans. Studies designed to validate the effectiveness of human observers at identifying target species neglected to test observers during summer months when the conditions were more challenging than during winter along snowmobile trails (Prugh and Ritland 2005).

Questions of independence and randomness always abound with diet studies due to clumping of samples located at kill sites or along roads, however we believe we uphold these assumptions. The working dogs are not motivated by visual cues, sex, age or species of a sample rather by locating the target and receiving their reward. Detector dogs offer a more dynamic approach to research; randomly deposited scat samples are actively located throughout the landscape and their detection does not interfere with daily routines of wildlife. In addition, sampling is not predicated on inducing a response to scented lures, therefore the data reflect the true interactions of individuals and populations with the landscape and natural processes which dictate their movement patterns. An additional consequence of clumped or observer based sampling is the lack of representation of the entire population, with the dogs and genetic analysis we know we surveyed a significant number of individuals during each sampling session. Our method allows us to circumvent these concerns.

Sampling in a design with overlaying grids where grid size is a function of the smallest known home range of the target species in similar habitats or locales or from a pilot study, ensures sufficient population wide coverage (Beckmann 2006). Our grid footprint extended beyond the calving areas to prevent bias associated with non-independence and clustering of prey (in particular, caribou calves) and, potentially, scats. Employing detector dogs increased re-sampling of individuals over time due to the overall effectiveness of the method, resulting in decreased error and improved precision of population estimates, as sampling incorporates more observations per individuals over greater area (Miller et al 2005). Furthermore, surveys were relatively short (a study area was surveyed in 2-3 weeks) and frequent (repeated in each ecological season) to cover large areas and investigate unique interactions, such as availability and predation upon calves.

To assess diet we maximized the quantity of samples collected throughout the field season. Straight-line transects or other structured sampling approaches which are common with hair snares, track plates, and camera traps are often less effective with dog surveys due to the fluid nature of the search pattern and responses to stochastic environmental characteristics such as wind pattern and scat presence. However, gridded approaches or targeting search areas can work with both. To compensate for the probability of missing detections due to one-time encounter of a one-day dog survey, a component of repeatability can be incorporated into a sampling design as well. Factors including the range of the target species, abundance, density, habitat, seasonal variation and research goals are incorporated into the design. All of these factors influence distance covered/day and detection rates and ensure sufficient opportunities to capture an adequate number of samples to complete a statistically robust analysis.

Considerable published and anecdotal evidence enumerates benefits of detector dogs' familiarization with a particular species odors and terrain searched (Smith et al. 2003, Beckmann 2006). Consequently, we consulted with colleagues in Newfoundland and reviewed relevant literature to identify the main predators of caribou calves and focused on their detection. Surveying efficiency can be compromised as a result layering with additional species (more species taught to detect or odors to recognize); therefore, our conservative approach increased our confidence in the sampling regimen. Focusing on a finite number of species which are repetitively reinforced through methodical training exercises by our experienced trainer and handlers increased the opportunities for successful detection. Therefore we acquired and trained working dogs for exclusive use for this research.

### **Conclusions**

Our research objective was twofold; qualitatively describe the diet of Newfoundland predators and to identify which predators, if any, were preying upon caribou calves. We did not have reliable prey abundance data so examining predation as a consequence of availability would not be possible quantitatively. However, we do know that the calves of both moose and caribou are seasonally available and vulnerable to predation. Meanwhile, ants, a primary target for black bears, were available both inside and outside the calving grounds in forested patches impacted by blowdown or human activity. By design, we finished sampling prior to the emergence of blueberries which represented a stationary, low risk and high reward prey item. Previously, we learned that once berries emerge we would have a difficult time moving through areas with a high bush density due to the high encounter rate of target scats.

Table 2.1. Sample size of black bear (N = 392) scats collected in various study areas in Newfoundland, Canada from 2009 to 2010.

Study Area	Year	1 - 27 June		28 June - 31 August	
		In	Out	In	Out
LP	2009	0	24	0	23
MR	2010	0	0	25	30
NP	2009	14	3	46	31
	2010	11	75	65	46
Total		25	102	136	130

Table 2.2. Sample size of coyote (N =414) scats collected in various study areas in Newfoundland, Canada from 2009 to 2010.

Study Area	Year	1 - 27 June		28 June - 31 August	
		In	Out	In	Out
LP	2009	5	23	2	87
MR	2010	0	0	42	61
NP	2009	1	14	3	39
	2010	18	23	28	68
Total		24	60	75	255

Table 2.3. Bear samples with number of items per scat when wood is included as a prey item and without.

Number of items	With wood	Without wood
1	78	123
2	145	158
3	105	64
4	51	47
5	14	1

Number of items	With wood	Without wood
1	20	31
2	37	40
3	27	16
4	13	12
5	4	0

Table 2.4. Number of food items per coyote scat.

Number of items	Samples
1	200
2	149
3	57
4	7
5	1

Number of items	Samples
1	48
2	36
3	14
4	2
5	0

Table 2.5. List of mammals of Newfoundland; indigenous, introduced and extinct.

**Indigenous mammals (13)**

- Bats: (1) Little Brown Bat (*Myotis lucifugus*), (2) Keen's Bat  
Hare: (3) Arctic hare (*Lepus arcticus*)  
Rodent: (4) Beaver (*Castor canadensis*), (5) Muskrat (*Ondatra zibethicus*), (6) Meadow vole (*Microtus pennsylvanicus*)  
Carnivore: (7) Red fox (*Vulpes vulpes*), (8) Black bear (*Ursus americanus*), (9) River otter (*Lutra canadensis*), (10) Ermine (*Mustela ermine*), (11) Newfoundland pine marten (*Martes americana atrata*), (12) Lynx (*Lynx canadensis*)  
Deer: (13) Woodland caribou (*Rangifer tarandus caribou*)

**Introduced mammals (14)**

- Hare: (14) Snowshoe hare (*Lepus americanus*)  
Rodent: (15) House mouse (*Mus musculus*), (16) Norway rat (*Rattus norvegicus*), (17) Masked shrew (*Sorex cinerus*), (18) Red squirrel (*Tamiasciurus hudsonicus*), (19) Eastern chipmunk (*Tamias striatus*), (20) White footed deer mouse (*Peromyscus maniculatus*),  
(21) Red backed vole  
Voles (offshore) (22) Gapper's Red-backed vole (*Myodes gapperi*), (23) Large-toothed Red-back vole (*Clethrionomys rufocanus*), (24) Bank vole (*Myodes glareolus*)  
Carnivore: (25) Mink (*Mustela vison*), (26) Eastern coyote (*Canis latrans*)  
Deer: (27) Moose (*Alces alces*)

**Extirpated species**

- Carnivore: (1) Grey wolf (*Canis lupus*)

Table 2.6. Frequency of occurrence per scat, expressed as a percentage, in all black bear scats collected and analyzed inside and outside caribou calving grounds (Rayl et al. 2014) in Newfoundland during two seasons; calving (1 – 27 June) and summer (28 – June to 31 – August).

	LaPoile		Middle Ridge		Northern Peninsula							
	2009		2010		2009				2010			
	Calving	Summer	Summer		Calving	Summer			Calving		Summer	
	Out	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Samples	24	23	25	30	14	3	46	31	11	75	65	46
Beaver	0	0	0	10	0	0	0	0	0	9	2	0
Caribou	21	17	48	33	43	67	17	23	45	51	17	13
Adult	4	13	40	30	29	67	17	16	36	33	11	13
Calf	17	4	16	7	14	0	0	6	9	19	5	0
Moose	42	22	16	7	29	100	17	52	0	57	15	24
Adult	38	17	16	7	29	100	17	52	0	52	14	24
Calf	4	4	0	0	0	0	0	0	0	5	3	0
Snowshoe Hare	0	0	32	20	0	0	0	0	0	7	2	7
Ants	58	91	68	83	7	33	54	65	18	51	43	59
Beetle	8	17	0	0	0	0	0	3	0	0	0	0
Grass	79	39	68	70	79	100	63	42	45	85	72	78
Mast	4	0	0	0	7	0	20	3	0	0	0	0
Needles	0	0	0	0	0	0	0	0	0	17	0	2
Seeds	0	0	0	0	0	0	2	13	55	3	17	9
Wood	4	78	36	50	7	0	33	55	9	19	32	43

Table 2.7. Frequency of occurrence per food item (%) in all black bear scats collected and analyzed inside and outside caribou calving grounds (Rayl et al. 2014) in Newfoundland during two seasons; calving (1 – 27 June) and summer (28 – June to 31 – August).

	LaPoile		Middle Ridge				Northern Peninsula					
	2009		2010		2009		2010					
	Calving	Summer	Summer		Calving	Summer	Calving		Summer			
	Out	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Total Items	52	64	69	84	24	9	95	79	19	225	130	108
Beaver	0	0	0	4	0	0	0	0	0	3	1	0
Caribou	2	5	14	11	17	22	8	6	21	11	5	6
Caribou calf	8	2	6	2	8	0	0	3	5	6	2	0
Moose	17	6	6	2	17	33	8	20	0	17	7	10
Moose calf	2	2	0	0	0	0	0	0	0	2	2	0
Snowshoe hare	0	0	12	7	0	0	0	0	0	2	1	3
Ants	27	34	25	30	4	11	26	25	11	17	22	25
Beetle	4	6	0	0	0	0	0	1	0	0	0	0
Grass	37	16	25	26	46	33	31	16	26	28	36	33
Mast	2	0	0	0	4	0	9	1	0	0	0	0
Needles	0	0	0	0	0	0	0	0	0	6	0	1
Seeds	0	0	0	0	0	0	1	5	32	1	8	4
Wood	2	30	13	18	4	0	16	22	5	6	16	19

Table 2.8. Frequency of occurrence per scat, expressed as a percentage, in all coyote scats collected and analyzed inside and outside caribou calving grounds (Rayl et al. 2014) in Newfoundland during two seasons; calving (1 – 27 June) and summer (28 – June to 31 – August).

	LaPoile				Middle Ridge		Northern Peninsula							
	2009		Summer		2010		2009		Summer		2010		Summer	
	Calving	Summer	Calving	Summer	Calving	Summer	Calving	Summer	Calving	Summer	Calving	Summer	Calving	Summer
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
Samples	5	23	2	87	42	61	1	14	3	39	18	23	28	68
Beaver	0	4	0	7	5	10	0	0	33	13	0	4	7	7
Caribou	60	43	100	46	52	36	100	29	33	41	67	57	64	46
Adult	60	22	50	25	29	18	100	29	0	18	28	43	39	26
Calf	0	22	50	21	19	18	0	0	33	23	44	13	32	19
Moose	20	78	0	47	26	10	0	36	33	51	44	43	21	37
Adult	20	70	0	40	24	10	0	36	33	51	44	43	18	34
Calf	0	9	0	7	0	0	0	0	0	0	0	0	4	3
Red back vole	20	9	0	6	5	8	0	0	0	3	0	4	7	15
Red squirrel	20	0	0	8	0	0	0	0	33	8	0	0	0	0
Snowshoe Hare	60	48	0	45	50	80	0	71	0	74	33	61	61	49
Adult	60	48	0	44	45	79	0	71	0	74	33	52	57	49
Juvenile	0	0	0	7	7	13	0	7	0	8	0	9	4	0
Ants	0	0	0	0	0	11	0	0	0	0	6	0	0	0
Grass	0	0	0	0	55	2	0	0	0	0	11	9	0	9
Seeds	0	0	0	0	5	2	0	0	0	0	0	0	4	13

Table 2.9. Frequency of occurrence per food item (%) in all coyote cats collected and analyzed inside and outside caribou calving grounds (Rayl et al. 2014) in Newfoundland during two seasons; calving (1 – 27 June) and summer (28 – June to 31 – August).

	LaPoile				Middle Ridge				Northern Peninsula							
	2009				2010				2009				2010			
	Calving		Summer		Summer		Calving		Summer		Calving		Summer			
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out		
Total Items	9	42	2	143	67	117	1	20	4	77	30	41	48	119		
Beaver	0	2	0	4	3	5	0	0	25	6	0	2	4	4		
Caribou	33	12	50	15	18	10	100	20	0	9	17	24	23	15		
Caribou calf	0	12	50	13	12	9	0	0	25	12	27	7	19	11		
Moose	11	38	0	24	15	5	0	25	25	26	27	24	10	19		
Moose calf	0	5	0	4	0	0	0	0	0	0	0	0	2	2		
Red back vole	11	5	0	3	3	4	0	0	0	1	0	2	4	8		
Red squirrel	11	0	0	5	0	0	0	0	25	4	0	0	0	0		
Snowshoe hare	33	26	0	27	28	41	0	50	0	38	20	29	33	28		
Juvenile hare	0	0	0	4	4	7	0	5	0	4	0	5	2	0		
Ants	0	0	0	0	0	6	0	0	0	0	3	0	0	0		
Grass	0	0	0	0	13	12	0	0	0	0	7	5	0	5		
Seeds	0	0	0	0	3	0	0	0	0	0	0	0	2	8		

Table 2.10. Percent food type occurrence in black bear scats collected and analyzed outside of the LaPoile caribou calving ground (Rayl et al. 2014) in Newfoundland in 2009.

Item	1 - 27 June (24) <sup>a</sup>	28 June - 31 August (23)
Beaver	0	0
Caribou	21	17
Adult	4	13
Calf	17	4
Moose	42	22
Adult	38	17
Calf	4	4
Snowshoe Hare	0	0
Ants	58	91
Beetle	8	17
Grass	79	39
Mast	4	0
Needles	0	0
Seeds	0	0
Wood	4	78

<sup>a</sup> Number of scats

Table 2.11. Frequency of occurrence per scat (%) of food items in black bear scats collected from 28 June – 31 August inside and outside of the Middle Ridge caribou calving area, south-central Newfoundland, in 2010.

Item	Inside (25) <sup>a</sup>	Outside (30)
Beaver	0	10
Caribou	48	33
Adult	40	30
Calf	16	7
Moose	16	7
Adult	16	7
Calf	0	0
Snowshoe Hare	32	20
Ants	68	83
Beetle	0	0
Grass	68	70
Mast	0	0
Needles	0	0
Seeds	0	0
Wood	36	50

<sup>a</sup> Number of scats

Table 2.12. Frequency of occurrence per scat, expressed as a percentage, in black bear scats collected and analyzed inside and outside the Northern Peninsula caribou calving ground (Rayl et al. 2014) in Newfoundland in 2009.

Item	2009				2010			
	1 - 27 June		28 June - 31 August		1 - 27 June		28 June - 31 August	
	Inside (14) <sup>a</sup>	Outside (3)	Inside (46)	Outside (31)	Inside (11)	Outside (75)	Inside (65)	Outside (46)
Beaver	0	0	0	0	0	9	2	0
Caribou	43	67	17	23	45	51	17	13
Adult	29	67	17	16	36	33	11	13
Calf	14	0	0	6	9	19	5	0
Moose	29	100	17	52	0	57	15	24
Adult	29	100	17	52	0	52	14	24
Calf	0	0	0	0	0	5	3	0
Snowshoe Hare	0	0	0	0	0	7	2	7
Ants	7	33	54	65	18	51	43	59
Beetle	0	0	0	3	0	0	0	0
Grass	79	100	63	42	45	85	72	78
Mast	7	0	20	3	0	0	0	0
Needle	0	0	0	0	0	17	0	2
Seeds	0	0	2	13	55	3	17	9
Wood	7	0	33	55	9	19	32	43

<sup>a</sup> Number of scats

Table 2.13. Frequency of occurrence per scat (%) of food items in black bear scats collected from 1 – 27 June inside the Northern Peninsula calving area.

Item	2009 (14) <sup>a</sup>	2010 (11)
Beaver	0	0
Caribou	43	23
Adult	29	16
Calf	14	6
Moose	29	52
Adult	29	52
Calf	0	0
Snowshoe Hare	0	0
Ants	7	65
Beetle	0	3
Grass	79	42
Mast	7	3
Needle	0	0
Seeds	0	13
Wood	7	55

<sup>a</sup> Number of scats

Table 2.14. Frequency of occurrence per scat (%) of food items in black bear scats collected from 1 – 27 June outside of two calving grounds in Newfoundland.

Item	2009		2010
	LaPoile (24) <sup>a</sup>	Northern Peninsula (3)	Northern Peninsula (75)
Beaver	0	0	9
Caribou	17	67	51
Adult	13	67	33
Calf	4	0	19
Moose	22	100	57
Adult	17	100	52
Calf	4	0	5
Snowshoe Hare	0	0	7
Ants	91	33	51
Beetle	17	0	0
Grass	39	100	85
Mast	0	0	0
Needles	0	0	17
Seeds	0	0	3
Wood	78	0	19

<sup>a</sup> Number of scats

Table 2.15. Frequency of occurrence per scat (%) of food items in black bear scats collected from 28 June – 31 August inside two caribou calving areas in Newfoundland.

Item	2009	2010	
	Northern Peninsula (46) <sup>a</sup>	Middle Ridge (25)	Northern Peninsula (65)
Beaver	0	0	2
Caribou	17	48	17
Adult	17	40	11
Calf	0	16	5
Moose	17	16	15
Adult	17	16	14
Calf	0	0	3
Snowshoe Hare	0	32	2
Ants	54	68	43
Beetle	0	0	0
Grass	63	68	72
Mast	20	0	0
Needles	0	0	0
Seeds	2	0	17
Wood	33	36	32

<sup>a</sup> Number of scats

Table 2.16. Frequency of occurrence per scat (%) of food items in black bear scats collected from 28 June – 31 August outside the caribou calving area for three study areas in Newfoundland.

Item	2009		2010	
	LaPoile (23) <sup>a</sup>	Northern Peninsula (31)	Middle Ridge (30)	Northern Peninsula (46)
Beaver	0	0	10	0
Caribou	17	23	33	13
Adult	13	16	30	13
Calf	4	6	7	0
Moose	22	52	7	24
Adult	17	52	7	24
Calf	4	0	0	0
Snowshoe Hare	0	0	20	7
Ants	91	65	83	59
Beetle	17	3	0	0
Grass	39	42	70	78
Mast	0	3	0	0
Needles	0	0	0	2
Seeds	0	13	0	9
Wood	78	55	50	43

<sup>a</sup> Number of scats

Table 2.17. Minimum number of individual black bears (total unique individuals detected = 71) sampled per session based on genetic identification (NA = no samples located).

Study Area	Year	1 - 27 June		28 June - 31 August	
		In	Out	In	Out
LP	2009	NA	7	NA	8
MR	2010	NA	NA	11	6
NP	2009	3	0	8	3
	2010	2	6	11	9
Total		5	13	30	26

Table 2.18. A comparison of the frequency of occurrence per scat (%) of food items in all bear scats collected from inside the Northern Peninsula calving ground (Rayl et al. 2014) versus individually identified bears from 1 – 27 June in Newfoundland in 2009.

Item	All (14) <sup>a</sup>	Without (11)	Individual 41 (3)
Beaver	0	0	0
Caribou	43	36	67
Adult	29	18	67
Calf	14	18	0
Moose	29	36	0
Adult	29	36	0
Calf	0	0	0
Snowshoe Hare	0	0	0
Ants	7	9	0
Beetle	0	0	0
Grass	79	73	100
Mast	7	9	0
Needle	0	0	0
Seeds	0	0	0
Wood	7	9	0

<sup>a</sup> Number of scats

Table 2.19 A comparison of the frequency of occurrence per scat (%) of food items in all bear scats collected from inside the Northern Peninsula calving ground (Rayl et al. 2014) versus individually identified bears from 28 June – 31 August in Newfoundland in 2009.

Item	All (46) <sup>a</sup>	Without (36)	Individual 40 (3)	Individual 42 (7)
Beaver	0	0	0	0
Caribou	17	17	67	0
Adult	17	17	67	0
Calf	0	0	0	0
Moose	17	22	0	0
Adult	17	22	0	0
Calf	0	0	0	0
Snowshoe Hare	0	0	0	0
Ants	54	64	33	14
Beetle	0	0	0	0
Grass	63	58	67	86
Mast	20	6	33	86
Needle	0	0	0	0
Seeds	2	3	0	0
Wood	33	42	0	0

<sup>a</sup> Number of scats

Table 2.20. A comparison of the frequency of occurrence per scat (%) of food items in all bear scats collected from inside the Northern Peninsula calving ground (Rayl et al. 2014) versus individually identified bears from 28 June – 31 August in Newfoundland in 2010.

Item	All (65) <sup>a</sup>	Without (56)	Individual 96 (5)	Individual 251 (4)
Beaver	2	2	0	0
Caribou	17	18	20	0
Adult	11	11	20	0
Calf	5	5	0	0
Moose	15	16	0	25
Adult	14	14	0	25
Calf	3	4	0	0
Snowshoe Hare	2	2	0	0
Ants	43	46	20	25
Beetle	0	0	0	0
Grass	72	79	60	0
Mast	0	0	0	0
Needle	0	0	0	0
Seeds	17	11	40	75
Wood	32	30	60	25

<sup>a</sup> Number of scats

Table 2.21. A comparison of the frequency of occurrence per scat (%) of food items in all bear scats collected from outside the Northern Peninsula calving ground (Rayl et al. 2014) versus individually identified bears from 28 June – 31 August in Newfoundland in 2010.

Item	All (46) <sup>a</sup>	Without (39)	Individual 241 (3)	Individual 243 (4)
Beaver	0	0	0	0
Caribou	13	15	0	0
Adult	13	15	0	0
Calf	0	0	0	0
Moose	24	28	0	0
Adult	24	28	0	0
Calf	0	0	0	0
Snowshoe Hare	7	8	0	0
Ants	59	64	33	25
Beetle	0	0	0	0
Grass	78	74	100	100
Mast	0	0	0	0
Needle	2	3	0	0
Seeds	9	3	0	75
Wood	43	44	33	50

<sup>a</sup> Number of scats

Table 2.22. Frequency of occurrence per scat (%) of food items in coyote scats collected and analyzed inside and outside the LaPoile caribou calving ground (Rayl et al. 2014) in Newfoundland in 2009.

Item	1 - 27 June		28 June - 31 August	
	Inside (5) <sup>a</sup>	Outside (23)	Inside (2)	Outside (87)
Beaver	0	4	0	7
Caribou	60	43	100	46
Adult	60	22	50	25
Calf	0	22	50	21
Moose	20	78	0	47
Adult	20	70	0	40
Calf	0	9	0	7
Red back vole	20	9	0	6
Red squirrel	20	0	0	8
Snowshoe Hare	60	48	0	45
Adult	60	48	0	44
Juvenile	0	0	0	7
Ants	0	0	0	0
Grass	0	0	0	0
Seeds	0	0	0	0

<sup>a</sup> Number of scats

Table 2.23. Frequency of occurrence per scat, expressed as a percentage, in coyote scats collected from 28 June – 31 August in the Middle Ridge, Newfoundland, in 2010.

Item	Inside (42) <sup>a</sup>	Outside (61)
Beaver	5	10
Caribou	52	36
Adult	29	18
Calf	19	18
Moose	26	10
Adult	24	10
Calf	0	0
Red back vole	5	8
Red squirrel	0	0
Snowshoe Hare	50	80
Adult	45	79
Juvenile	7	13
Ants	0	11
Grass	55	2
Seeds	5	2

<sup>a</sup> Number of scats

Table 2.24. Frequency of occurrence per scat, expressed as a percentage, in coyote scats collected and analyzed inside and outside the Northern Peninsula caribou calving ground (Rayl et al. 2014) in Newfoundland in 2009 and 2010.

Item	2009				2010			
	1 - 27 June		28 June - 31 August		1 - 27 June		28 June - 31 August	
	Inside (1) <sup>a</sup>	Outside (14)	Inside (3)	Outside (39)	Inside (18)	Outside (23)	Inside (28)	Outside (68)
Beaver	0	0	33	13	0	4	7	7
Caribou	100	29	33	41	67	57	64	46
Adult	100	29	0	18	28	43	39	26
Calf	0	0	33	23	44	13	32	19
Moose	0	36	33	51	44	43	21	37
Adult	0	36	33	51	44	43	18	34
Calf	0	0	0	0	0	0	4	3
Red back vole	0	0	0	3	0	4	7	15
Red squirrel	0	0	33	8	0	0	0	0
Snowshoe Hare	0	71	0	74	33	61	61	49
Adult	0	71	0	74	33	52	57	49
Juvenile	0	7	0	8	0	9	4	0
Ants	0	0	0	0	6	0	0	0
Grass	0	0	0	0	11	9	0	9
Seeds	0	0	0	0	0	0	4	13

<sup>a</sup>Number of scat

Table 2.25. Frequency of occurrence per scat (%) of food items in coyote scats collected from 1 – 27 June inside caribou calving areas in Newfoundland.

Item	2009		2010
	LaPoile (5) <sup>a</sup>	Northern Peninsula (1)	Northern Peninsula (18)
Beaver	0	0	0
Caribou	60	100	67
Adult	60	100	28
Calf	0	0	44
Moose	20	0	44
Adult	20	0	44
Calf	0	0	0
Red back vole	20	0	0
Red squirrel	20	0	0
Snowshoe Hare	60	0	33
Adult	60	0	33
Juvenile	0	0	0
Ants	0	0	6
Grass	0	0	11
Seeds	0	0	0

<sup>a</sup> Number of scats

Table 2.26. A comparison of the frequency of occurrence per scat (%) of food items in coyote scats collected outside of two different caribou calving ground from 1 – 27 June (Rayl et al. 2014).

Item	2009		2010
	LaPoile (23) <sup>a</sup>	Northern Peninsula (14)	Northern Peninsula (23)
Beaver	4	0	4
Caribou	43	29	57
Adult	22	29	43
Calf	22	0	13
Moose	78	36	43
Adult	70	36	43
Calf	9	0	0
Red back vole	9	0	4
Red squirrel	0	0	0
Snowshoe Hare	48	71	61
Adult	48	71	52
Juvenile	0	7	9
Ants	0	0	0
Grass	0	0	9
Seeds	0	0	0

<sup>a</sup> Number of scats

Table 2.27. A comparison of the frequency of occurrence per scat (%) of food items in coyote scats collected outside caribou calving ground from 28 June – 31 August (Rayl et al. 2014).

Item	2009		2010	
	LaPoile (2) <sup>a</sup>	Northern Peninsula (3)	Middle Ridge (42)	Northern Peninsula (28)
Beaver	0	33	5	7
Caribou	100	33	52	64
Adult	50	0	29	39
Calf	50	33	19	32
Moose	0	33	26	21
Adult	0	33	24	18
Calf	0	0	0	4
Red back vole	0	0	5	7
Red squirrel	0	33	0	0
Snowshoe Hare	0	0	50	61
Adult	0	0	45	57
Juvenile	0	0	7	4
Ants	0	0	0	0
Grass	0	0	55	0
Seeds	0	0	5	4

<sup>a</sup> Number of scats

Table 2.28. A comparison of the frequency of occurrence per scat (%) of food items in coyote scats collected outside of the caribou calving ground from 28 June – 31 August (Rayl et al. 2014).

Item	2009		2010	
	LaPoile (87)	Northern Peninsula (39)	Middle Ridge (61)	Northern Peninsula (68)
Beaver	7	13	10	7
Caribou	46	41	36	46
Adult	25	18	18	26
Calf	21	23	18	19
Moose	47	51	10	37
Adult	40	51	10	34
Calf	7	0	0	3
Red back vole	6	3	8	15
Red squirrel	8	8	0	0
Snowshoe Hare	45	74	80	49
Adult	44	74	79	49
Juvenile	7	8	13	0
Ants	0	0	11	0
Grass	0	0	2	9
Seeds	0	0	2	13

<sup>a</sup> Number of scats

Table 2.29. Minimum number of individual (total unique individuals detected = 79) coyotes sampled per session based on genetic identification when samples were present (NA = no samples).

Study Area	Year	1 - 27 June		28 June - 31 August	
		In	Out	In	Out
LP	2009	1	4	2	12
MR	2010	NA	NA	7	16
NP	2009	1	2	3	14
	2010	3	9	5	16
Total		5	15	17	58

Table 2.30. A comparison of the frequency of occurrence per scat (%) of food items in all coyote scats collected from outside the LaPoile caribou calving ground (Rayl et al. 2014) versus individually identified coyotes from 1 – 27 June in Newfoundland in 2009.

Item	All (23)	Without (20)	Individual 1 (3)
Beaver	4	5	0
Caribou	43	45	33
Adult	22	25	0
Calf	22	20	33
Moose	78	75	100
Adult	70	70	67
Calf	9	5	33
Red back vole	9	10	0
Red squirrel	0	0	0
Snowshoe Hare	48	50	33
Adult	48	50	33
Juvenile	0	0	0
Ants	0	0	0
Grass	0	0	0
Seeds	0	0	0

<sup>a</sup> Number of scats

Table 2.31. A comparison of the frequency of occurrence per scat (%) of food items in all coyote scats collected from outside the LaPoile caribou calving ground (Rayl et al. 2014) versus individually identified coyotes from 28 – June to 31 – August in Newfoundland in 2009.

Item	All (87) <sup>a</sup>	Without (49)	Individual 1 (4)	Individual 3 (7)	Individual 4 (25)	Individual 6 (3)
Beaver	7	6	0	0	4	67
Caribou	46	45	25	14	64	33
Adult	25	22	0	14	40	0
Calf	21	22	25	0	24	33
Moose	47	47	50	57	44	33
Adult	40	41	50	57	36	0
Calf	7	6	0	0	8	33
Red back vole	6	10	0	0	0	0
Red squirrel	8	8	0	14	8	0
Snowshoe Hare	45	51	50	29	36	33
Adult	44	49	50	29	36	33
Juvenile	7	6	25	0	8	0
Ants	0	0	0	0	0	0
Grass	0	0	0	0	0	0
Seeds	0	0	0	0	0	0

<sup>a</sup> Number of scats

Table 2.32. A comparison of the frequency of occurrence per scat (%) of food items in all coyote scats collected from outside the Middle Ridge caribou calving ground (Rayl et al. 2014) versus individually identified coyotes from 28 – June to 31 – August in Newfoundland in 2010.

Item	All (61)	Without (44)	Coyote 68 (5)	Coyote 76 (3)	Coyote 79 (3)	Coyote 81 (3)
Beaver	10	11	20	0	0	0
Caribou	36	34	40	67	0	33
Adult	18	21	20	0	0	33
Calf	18	15	20	67	0	0
Moose	10	11	0	0	33	0
Adult	10	11	0	0	33	0
Calf	0	0	0	0	0	0
Red back vole	8	4	0	33	33	33
Red squirrel	0	0	0	0	0	0
Snowshoe Hare	80	74	100	100	67	100
Adult	79	72	100	100	67	100
Juvenile	13	11	60	0	0	0
Ants	11	13	0	0	0	33
Grass	2	23	0	33	33	33
Seeds	2	0	0	0	0	0

<sup>a</sup> Number of scats

Table 2.33. A comparison of the frequency of occurrence per scat (%) of food items in all coyote scats collected from outside the Northern Peninsula caribou calving ground (Rayl et al. 2014) versus individually identified coyotes from 1 – 27 June in Newfoundland in 2009.

Item	All (14)	Without (8)	Individual 14 (3)	Individual 15 (3)
Beaver	0	0	0	0
Caribou	29	25	33	33
Adult	29	25	33	33
Calf	0	0	0	0
Moose	36	38	33	33
Adult	36	38	33	33
Calf	0	0	0	0
Red back vole	0	0	0	0
Red squirrel	0	0	0	0
Snowshoe Hare	71	75	67	67
Adult	71	75	67	67
Juvenile	7	13	0	0
Ants	0	0	0	0
Grass	0	0	0	0
Seeds	0	0	0	0

<sup>a</sup> Number of scats

Table 2.34. A comparison of the frequency of occurrence per scat (%) of food items in all coyote scats collected from outside the Northern Peninsula caribou calving ground (Rayl et al. 2014) versus individually identified coyotes from 28 – June to 31 – August in Newfoundland in 2009.

Item	All (39)	Without (18)	Individual 9 (3)	Individual 11 (5)	Individual 16 (9)	Individual 17 (4)
Beaver	13	17	0	0	11	25
Caribou	41	56	33	20	22	50
Adult	18	28	0	0	11	25
Calf	23	28	33	20	11	25
Moose	51	39	33	60	78	50
Adult	51	39	33	60	78	50
Calf	0	0	0	0	0	0
Red back vole	3	6	0	0	0	0
Red squirrel	8	11	0	0	11	0
Snowshoe Hare	74	56	100	60	100	100
Adult	74	56	100	60	100	100
Juvenile	8	6	0	0	11	25
Ants	0	0	0	0	0	0
Grass	0	0	0	0	0	0
Seeds	0	0	0	0	0	0

<sup>a</sup> Number of scats

Table 2.35 A comparison of the frequency of occurrence per scat (%) of food items in all coyote scats collected from inside the Northern Peninsula caribou calving ground (Rayl et al. 2014) versus individually identified coyotes from 1 – 27 June in Newfoundland in 2010.

Item	All (18)	Without (15)	Individual 103 (3)
Beaver	0	0	0
Caribou	67	73	33
Adult	28	27	33
Calf	44	53	0
Moose	44	40	67
Adult	44	40	67
Calf	0	0	0
Red back vole	0	0	0
Red squirrel	0	0	0
Snowshoe Hare	33	27	67
Adult	33	27	67
Juvenile	0	0	0
Ants	6	0	0
Grass	11	13	0
Seeds	0	7	0

<sup>a</sup> Number of scats

Table 2.36. A comparison of the frequency of occurrence per scat (%) of food items in all coyote scats collected from inside the Northern Peninsula caribou calving ground (Rayl et al. 2014) versus individually identified coyotes from 28 – June to 31 – August in Newfoundland in 2010.

Item	All (28)	Without (19)	Individual 28 (3)	Individual 46 (6)
Beaver	7	11	0	0
Caribou	64	63	67	67
Adult	39	32	67	50
Calf	32	37	33	17
Moose	21	21	0	33
Adult	18	16	0	33
Calf	4	5	0	0
Red back vole	7	11	0	0
Red squirrel	0	0	0	0
Snowshoe Hare	61	47	100	83
Adult	57	42	100	83
Juvenile	4	5	0	0
Ants	0	0	0	0
Grass	0	0	0	0
Seeds	4	5	0	0

<sup>a</sup> Number of scats

Table 2.37. A comparison of the frequency of occurrence per scat (%) of food items in all coyote scats collected from outside the Northern Peninsula caribou calving ground (Rayl et al. 2014) versus individually identified coyotes from 28 – June to 31 – August in Newfoundland in 2010.

Item	All (68)	Without (44)	Individual 13 (3)	Individual 16 (3)	Individual 52 (6)	Individual 95 (3)	Individual 97 (3)	Individual 98 (3)	Individual 110 (3)
Beaver	7	7	33	0	0	33	0	0	0
Caribou	46	48	100	33	17	33	33	33	0
Adult	26	27	100	0	0	0	33	33	0
Calf	19	20	0	33	17	33	0	0	0
Moose	37	41	33	67	17	0	0	0	100
Adult	34	36	33	67	17	0	0	0	100
Calf	3	5	0	0	0	0	0	0	0
Red back vole	15	16	0	33	0	33	0	0	33
Red squirrel	0	0	0	0	0	0	0	0	0
Snowshoe Hare	49	41	0	67	83	33	33	100	67
Adult	49	41	0	67	83	33	33	100	67
Juvenile	0	0	0	0	0	0	0	0	0
Ants	0	0	0	0	0	0	0	0	0
Grass	9	7	0	33	0	33	0	33	0
Seeds	13	5	0	0	17	33	100	67	0

<sup>a</sup> Number of scats

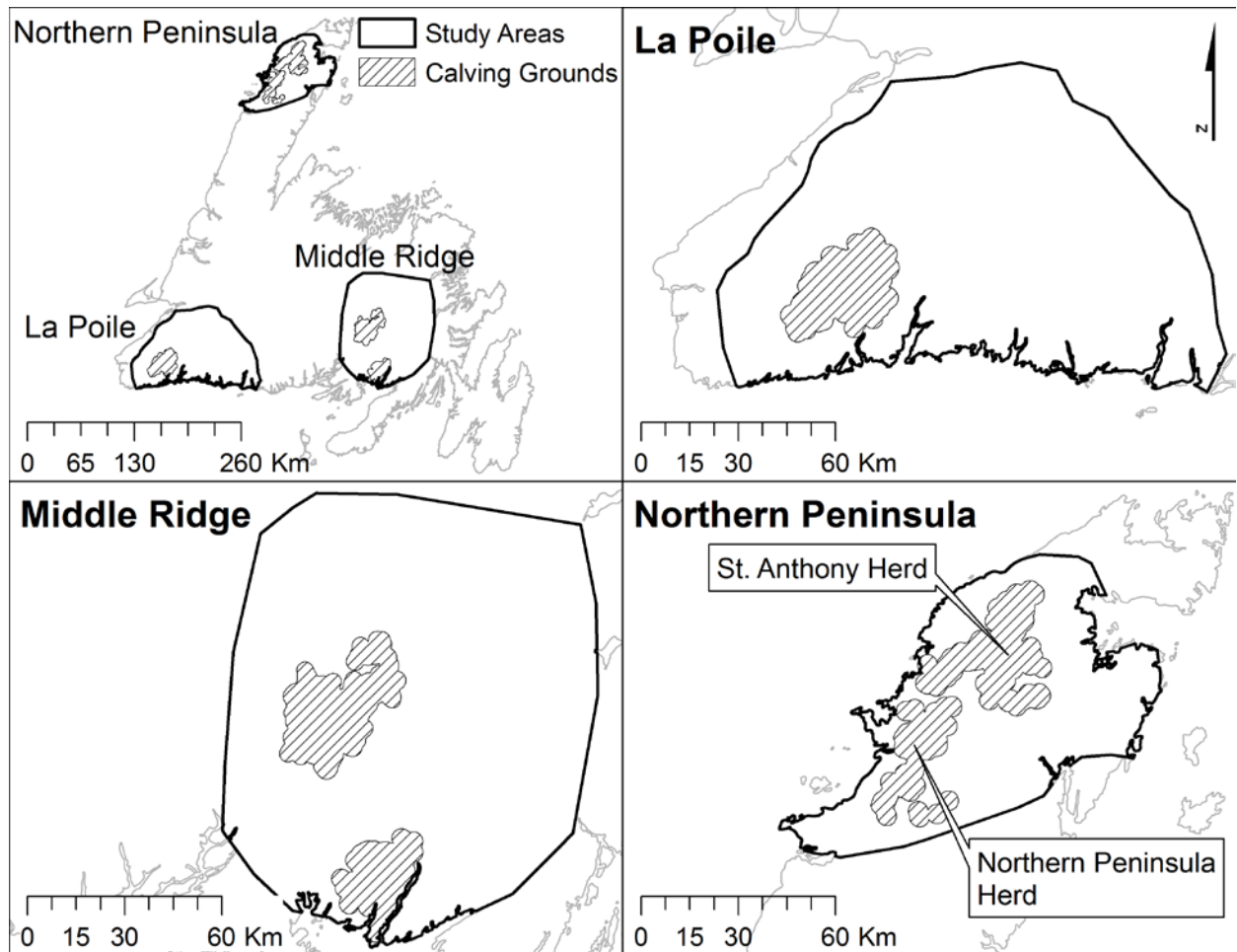


Figure 2.1 The location of caribou calving grounds for the La Poile herd in the La Poile study area, the Middle Ridge herd in the Middle Ridge study area, and the Northern Peninsula and St. Anthony herds in the Northern Peninsula study area, as identified from caribou calf telemetry locations from 2003-2010.

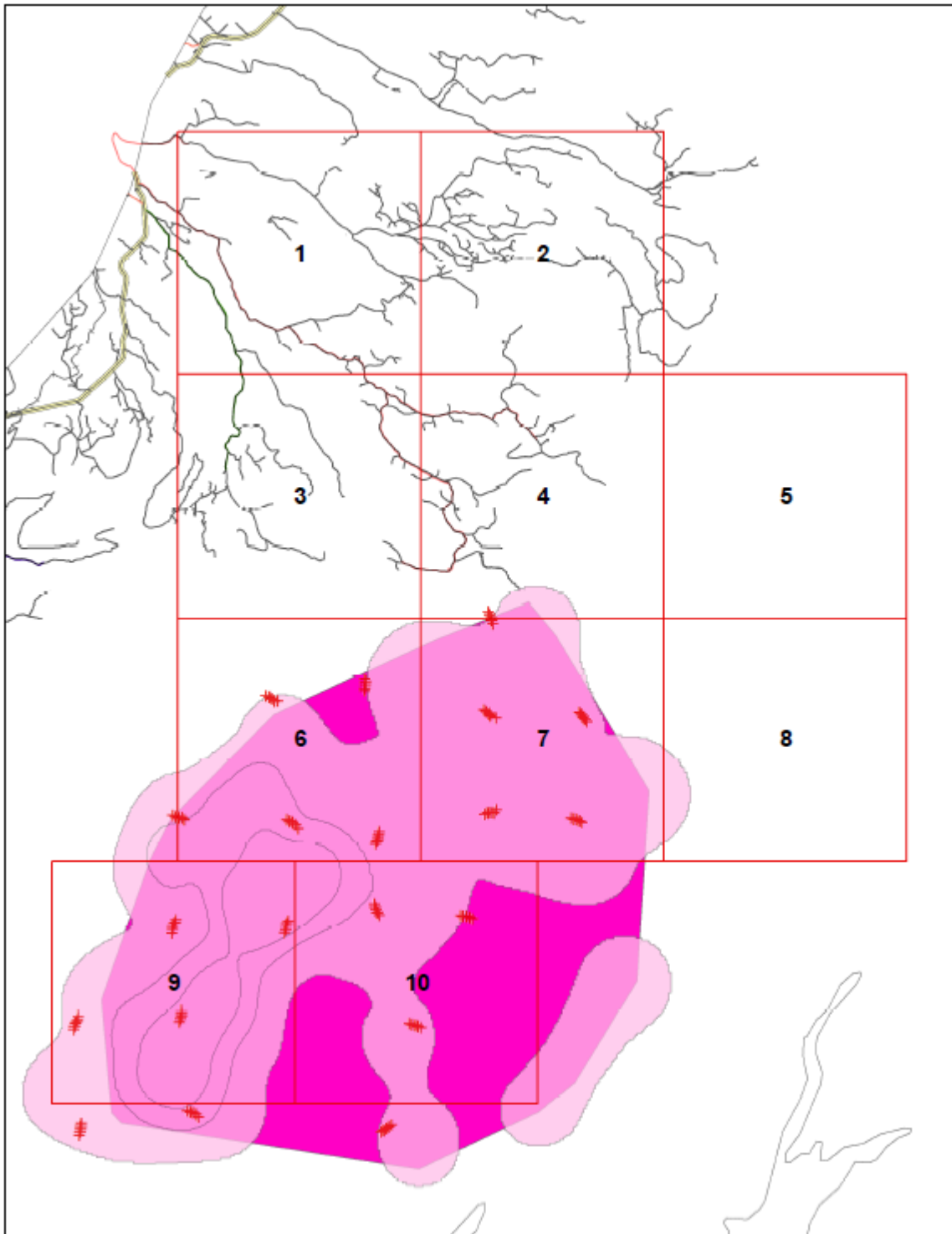


Figure 2.2. Scat sampling grids (12 km x 12 km) in the LaPoile study area with hair snare locations and calving ground boundary.

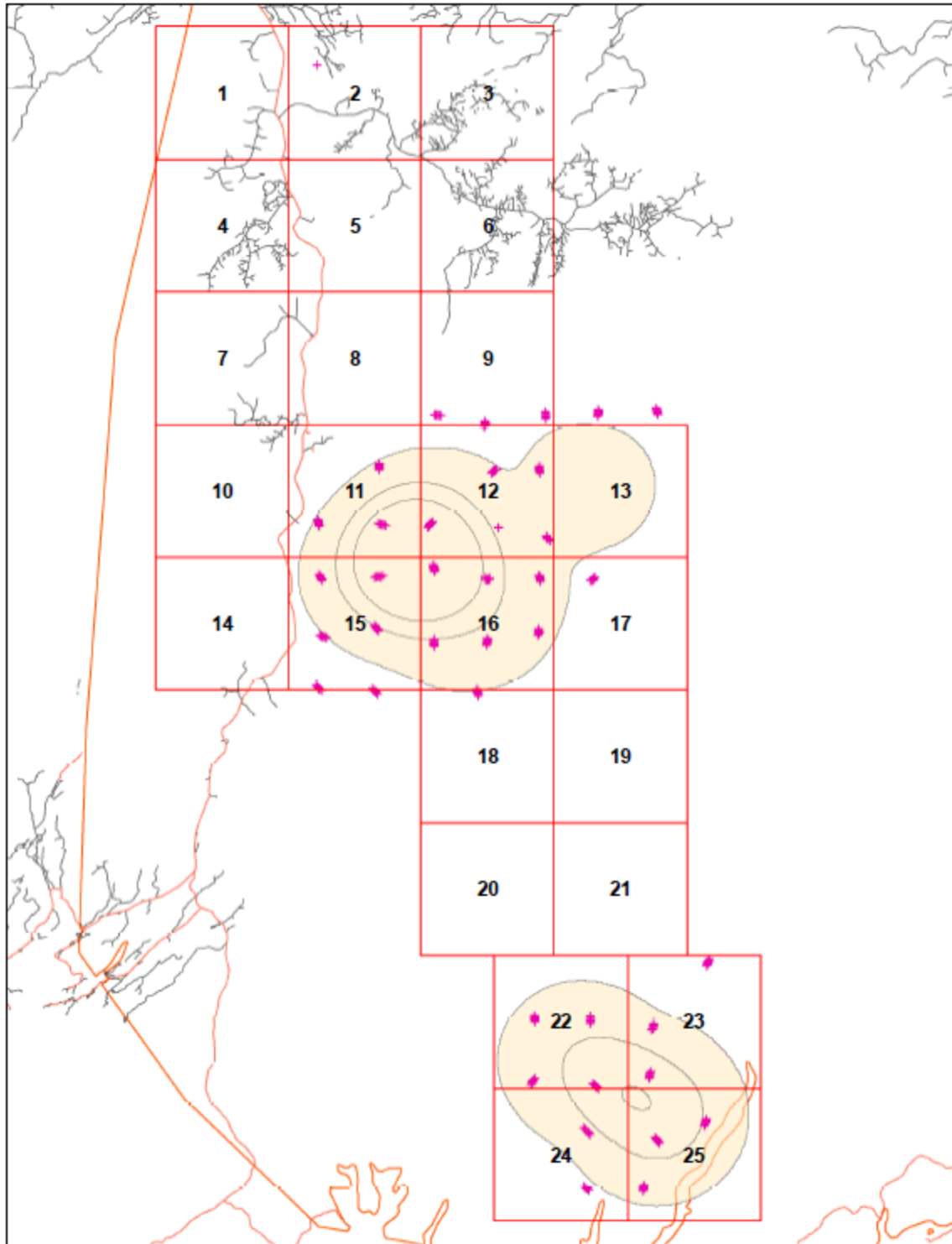


Figure 2.3. Scat sampling grids (12 km x 12 km) in the Middle Ridge study area with hair snare locations and calving ground boundary.

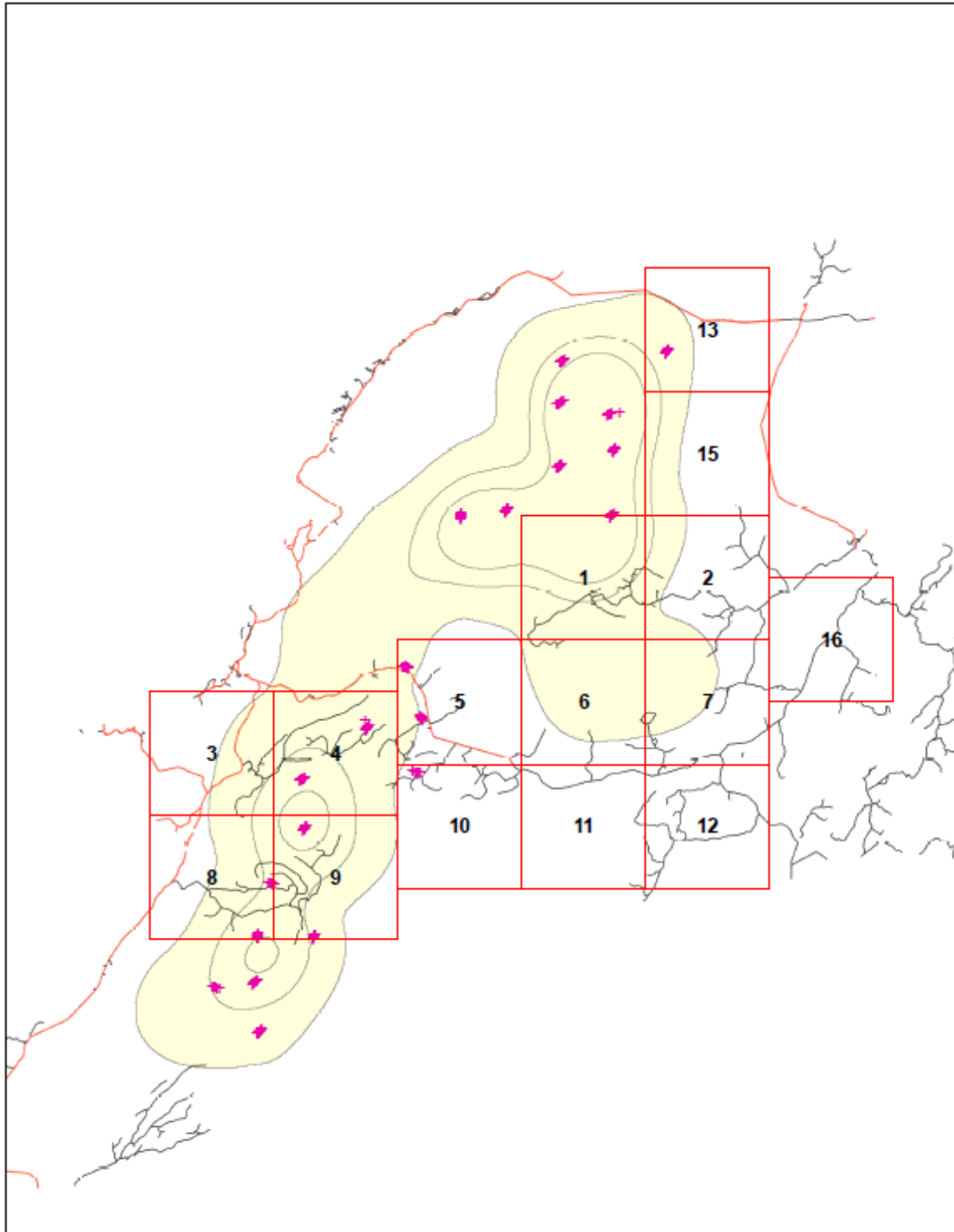


Figure 2.4. Scat sampling grids (12 km x 12 km) in the Northern Peninsula study area with hair snare locations and calving ground boundary.

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