Coyotes and their movement in relation to resources in Tommy Thompson Park

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A major paper submitted to the Faculty of Environmental Studies
in partial fulfillment of the requirements for the degree of

Master in Environmental Studies

York University
Toronto, Ontario, Canada

November 2014

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ABSTRACT

The coyote (*Canis latrans*) is a highly adaptable animal that has been pushing its territorial boundaries into urban landscapes. Most studies have focused on rural habitats, while urban coyote work examines their diet and human-coyote conflicts. This study investigated the movement and diet of the urban coyote to determine if a relationship exists between the coyote and its prey in Tommy Thompson Park. As an Important Bird Area, Tommy Thompson is known for its large migratory bird populations that utilize the park during the nesting season. This seasonal, abundant resource has the potential to affect the coyote's movements. In order to examine this relationship an adult male coyote was collared and movements tracked for six months, camera traps were deployed where nesting waterbirds are present in the spring and absent in the fall to determine percent occupancy differences, and scat samples were analyzed. Results indicate that coyotes were more likely to stay within park boundaries when migratory birds were present, however their diet did not indicate an increase in avian consumption during this time. Scat analysis did suggest a seasonal change in terrestrial prey items, which was attributed to abundance and availability. Understanding the relationship between the predator and prey is important in urban settings as it influences the unique ecosystem dynamics.

ACKNOWLEDGMENTS

It is my pleasure to thank all who made this degree and major paper possible. I would never have been able to finish without the guidance and support from my professors, family and friends.

I could not have succeeded without the encouragement, patience, guidance and support of my supervisor, Dr. Gail S. Fraser. You have inspired me to strive for academic excellence and this paper would not have been possible without you. Furthermore I would like to thank Dr. Gregory Thiemann who, as my advisor, provided advice regarding my Plan of Study and course selection throughout the first half of my Master's degree.

I am grateful to Brent Patterson at the Ontario Ministry of Natural Resources and Forestry (OMNRF), who provided valuable insight into coyote movement and allowed access to collar data. I would also like to thank Ashley McLaren and Scott Taylor at the OMNRF for taking the time to train me in scat analysis. GPS collar data was provided by the OMNRF.

I would like the thank Ian Sturdee, the Tommy Thompson Park wildlife biologist from the Toronto and Regional Conservation Authority, for opportunistically collecting and storing coyote scat samples.

My deepest appreciation goes to my parents for their support and encouragement throughout my degree, I am forever indebted. To my sister, I must say thank you for the late night conversations and last minute reviewing. I would like to thank my cousins, extended family and friends from Halifax, for their encouragement and no-nonsense support. Finally to my newly acquired York University friends, I thank you for your academic advice, stimulating conversations and de-stressing events.

To all those who supported me and this project in any respect, thank you.

FOREWORD

The Area of Concentration of my Plan of Study within the Master in Environmental Studies degree is entitled *Wildlife management and natural resource conservation*. Wildlife management is the dominant component of this paper. Management practices and methods were tested throughout this research to determine relationships between prey and movement. Through literature research, theories and implementation strategies were examined. Wildlife management techniques are unique to every environment and using a variety of appropriate methods, I was able to witness wildlife management in practice.

Although this research predominately contributed to the wildlife management component, both conservation biology and resource management elements can be found. Conservation biology's concepts and theories are present within this research, through investigating the diversity of prey available for coyotes to consume. Working within a conservation area does ensure that live resources are protected if they stay within the boundaries. However this paper also examines the potential ecosystem dynamics that can occur between the coyotes and their prey, further addressing conservation biology and resource management concepts.

Chapter 1. Introduction to Major Paper

The distribution of human populations throughout North America has changed drastically since the pioneer days and even the early 1900s. In the United States, over 80 percent of the human population is considered to be living in urbanized areas (Adams and Lindsey 2010), a number probably similarly representative to Canada's population distribution. As a result, the ideas and attitudes towards wildlife have changed. Adams and Lindsey (2010) suggest that people living in the city who have been there for several generations value wildlife in a similar way as a companion animal more than a consumptive resource. However, when misconceptions arise or wildlife threatens their safety or livelihood, then the wildlife must be eliminated (Adams and Lindsey 2010). The result is a need for managing urban wildlife.

In Adams' 1994 book, *Urban Wildlife Habitats: A Landscape Perspective*, the term *urban wildlife* was established. Adams suggested that urban wildlife species can be categorized as urban if they are found living in and around human settlements (1994). It is clear that developing a definition for urban wildlife is difficult, as it attempts to categorize species. Adams and Lindsey (2010) provide this definition: "urban wildlife includes all nondomestic vertebrate species, with population in areas classified as urban" (pg. 8). They note their distinction between vertebrate and invertebrate, as invertebrate species have a special classification and are not studied by wildlife biologists, but studied by specialists (entomologists, arachnologists and malacologists) (Adams and Lindsey 2010). Furthermore, Adams and Lindsey (2010) do not make the distinction between game species, as they are not considered game within urbanized areas, as people would not actively hunt them in commercial or residential areas.

Wildlife management, especially in an urban environment, is influenced by the needs of the people. Caughly (1977) outlines the four possibilities of management: make a population increase, make a population decrease, harvest the population for a continual yield or monitor the

population. Obviously these goals are determined by the state of the species, however, within urban wildlife management, the goal is often to make a population decrease or resolve human-wildlife conflicts (Decker et al. 2012). Decreasing the population in an urban environment can be difficult because many urbanized people frown upon harvesting, and using guns within city limits can be dangerous. Furthermore, many animal services and wildlife organizations do not practice management techniques that would result in the death of an animal. Urban wildlife managers are thus assigned the task of reducing wildlife population in unique ways, and educating the public to ensure safe wildlife interactions (Decker et al. 2012).

In many cases, managing wildlife involves creating an undesirable habitat for the species by manipulating an element required for survival (food, water or shelter) (Adams, 1994). Most often management techniques are used if there is a need to decrease a certain species' population, meaning there is an over abundance issue. However each situation must be analyzed carefully as addressing over abundance issues may not solve the problem or be the best approach (Decker et al. 2012). A preservation or 'hands-off' approach is often used in urban forests, as nature can often solve its own population problems (Adams, 1994). However, monitoring the issue is essential, as some species, such as deer, can degrade the habitat in populations where they are not controlled. Adams (1994) notes that a preservation approach to management is seldom practiced in urban areas as human influences are persistent and the natural areas are small.

Toronto prides itself on the amount of green spaces found in the city. Within city limits, there are over 1,600 parks and 600 kilometres of trails, which covers over 8,000, hectares (Parks, Forestry and Recreation 2013). This is roughly 13 percent of the city's land area (Parks, Forestry and Recreation 2013). Other comparable cities from the United States have over 16 percent of public green space (Boston has 16%, New York has 19.6%), although the average city has only

11 percent (Burgess 2009). Nonetheless, Toronto has provided habitats in which a variety of wildlife can live, finding food, water, protection and shelter nearby.

In 1993, around the time that scholars and cities began to recognize that urban wildlife management was an issue that needed to be discussed, the Toronto Wildlife Centre was created (Toronto Wildlife Centre 2011). It was formed to help "to provide rehabilitative care for sick, injured, and orphaned wildlife, and to help wildlife and people co-exist in an increasingly urban environment" (Toronto Wildlife Centre 2011). This centre has become the largest in Canada and networks with Toronto Animal Services, the City of Toronto and other wildlife centres across North America (Toronto Wildlife Centre 2011). This emphasizes that there is a need to understand and assist wildlife within urban environments, and Toronto is not immune.

In order to address the urban wildlife issue, the City of Toronto has played an active role in attempting to educate the public regarding urban wildlife. Toronto has provided *Wildlife in the City* profiles for coyotes, skunks, foxes, raccoons and squirrels. Similar to the City of Coquitlam, Toronto has also provided ways to *Wildlife-Proof Your Home* and *Wildlife-Proof Your Lawn* (City of Toronto 2013). The City of Toronto, Toronto Animal Services and the Toronto Wildlife Centre believe that education and outreach is the most efficient way to manage wildlife misunderstandings and issues.

Similar to many other cities, over the past few years Toronto has been attempting to address wildlife problems. While increased deer populations seem to plague many other cities provoking culls, Toronto had a deer problem but currently is more concerned with problems regarding its coyote population. The situation has escalated to the point that the City has created a *Coyote Response Strategy* to reduce the "negative interactions between humans, their pets and property, and coyotes" (City of Toronto 2013b). Unfortunately, when negative interactions occur

the public often calls for action to be taken, whether it involves removal of the coyote by translocation or lethal means (Scrivener 2013).

I have always felt the need to educate the public about predators. Ever since I was an outdoor educator, I have been committed to informing students about predators and their behaviours. I often find myself in arguments with people who are scared of predators or insist on killing them all. I believe that if people understood more about the species, their behaviours and movement, we could find a human-predator life balance. Of course this is an enormous task, but one to which I will never surrender.

The idea of research coyotes began after many local incidences of coyotes attacking dogs and small children were reported by news media. Then in February 2013, while I was preparing a presentation about cougars and their conflicts with people, a coyote was shot and killed by police in Toronto. According to witnesses the coyote looked 'aggressive', but had not hurt anyone. A month later Toronto City Councillor, Glenn De Baeremaeker, was interviewed by multiple media sources for attempting to impose a city wide ban on feeding coyotes, as well as killing and trapping. I was immediately inspired when I heard his interview with the CBC. Soon afterwards coyotes were at the forefront of my mind and research.

For over a year now I have conversed and sometimes argued with people, including family members, from all walks of life. I have been asked questions about coyote's behaviours, diets, movement, and conflicts with people. Sometimes people have shown interest in my research, and other times it seems that there is no room for argument, coyotes should be removed from the city, by any means necessary. Whatever the opinion I wanted to ensure I had a knowledgeable background about coyotes living in urban areas. Choosing to focus my research on Toronto's Leslie Street Spit was an added bonus due to proximity and local specialists.

To say that this paper was a 'piece of cake' would be an understatement. This paper has taken over a year to accomplish and it was not short on challenges. Researching literature proved to be somewhat difficult as urban coyote studies are not as prevalent as their rural counterparts. I attempted to gather as much information as possible regarding urban coyotes and focused my research on rural coyote movements, since this was largely ignored in built environments. Once complete, the next step was acquiring and analyzing the data.

Acquiring data was not as difficult as expected. I was very fortunate to have a supervisor with connections to the Ontario Ministry of Natural Resources and Forestry (OMNRF) and the Toronto and Region Conservation Authority (TRCA). Once the proposal was complete, these agencies were willing to support me. I was very fortunate to have taken a GIS course at the same time I was analyzing the GPS collar data, provided by the OMNRF. Any problems I experienced were discussed and easily corrected with the assistance of peers and professor.

Another challenged I experienced was the scat analysis. The first batch of samples were cleaned at the OMNRF facility at Trent University, Peterborough. The training was well done and I felt very welcomed and confident in my abilities after leaving. Unfortunately, the training occurred in June, leaving only a few weeks to analyze scat samples and complete the paper before the July deadline. It was difficult to arrange a training time with the OMNRF because the longer winter subsequently pushed their preparation for spring further into April and May. Thus, my studies were extended into the Fall term to ensure adequate time to finish the paper.

The first problem occurred when cuticular samples were not providing clear impressions on the slides. After attempting five samples, I changed the hair spray and the problem was solved, however it was unexpected and time-consuming. I then had to re-analyze the scat samples in order to ensure the proper animals were being identified. The scat analysis also took

much longer than expected, although the amount of time needed to identify the hairs did decreased over time. I certainly developed a skill at imprinting slides and analyzing their impressions. Throughout this process I learned that an efficient labelling and identification system is essential.

I will be the first to admit that I am not a mathematician or statistician but I do have confidence in my mathematical abilities. I attempted to analyze the percent occupancy from the camera traps by hand, since I did not have access to a statistical program, however constantly receiving errors tested my patience. It also took many hours to determine my mistakes and attempt to correct them. Once they were analyzed using a computer program, the problems were solved. It was difficult to accept that certain comparison between the percent occupancy could not be calculated due to insufficient data. It was certainly a challenge that was unexpected, however one that had to be accepted.

Experience has taught me that there will always be bumps and setbacks along the way; patience and perseverance is key. While I did extend my studies a semester, the final product for my degree is complete. The final goal for this paper is to have the manuscript published by the Wildlife Society Bulletin; therefore the format is somewhat different than that of a major paper. Where possible I have followed the Wildlife Society Bulletin formatting requirements, including proper referencing of literature. Prior to submission there will need to be wording changes and approval from agencies, however I will see this paper through to the end of publication. Although the work is far from over, I already feel rewarded.

Chapter 2. Coyotes and their movement in relation to resources in Tommy Thompson Park

Abstract. The coyote (*Canis latrans*) is a highly adaptable animal that has been pushing its territorial boundaries into urban landscapes. Most studies have focused on rural habitats, while urban coyote work examines their diet and human-coyote conflicts. This study investigated the movement and diet of the urban coyote to determine if a relationship exists between the coyote and its prey in Tommy Thompson Park. As an Important Bird Area, Tommy Thompson is known for its large migratory bird populations that utilize the park during the nesting season. This seasonal, abundant resource has the potential to affect the coyote's movements. In order to examine this relationship an adult male coyote was collared and movements tracked for six months, camera traps were deployed where nesting waterbirds are present in the spring and absent in the fall to determine percent occupancy differences, and scat samples were analyzed. Results indicate that coyotes were more likely to stay within park boundaries when migratory birds were present, however their diet did not indicate an increase in avian consumption during this time. Scat analysis did suggest a seasonal change in terrestrial prey items, which was attributed to abundance and availability. Understanding the relationship between the predator and prey is important in urban settings as it influences the unique ecosystem dynamics.

INTRODUCTION

Perceived as an icon of wilderness (Gehrt and Riley 2010), the coyote (*Canis latrans*) is an opportunistic mammal that is found throughout most of North America. Their ability to adapt to rural and urban habitats has seen their habitat range expand as land was cleared for agriculture and development (Grompper 2002). Urban habitats are especially appealing to coyotes, as white-tailed deer (*Odocoileus virginianus*), a common prey item of the coyote, has pushed their boundaries into developed areas. Furthermore, top predators that compete for resources such as bears (*Ursus arctos* and *Ursus americanus*), wolves (*Canis lupus*) and cougars (*Puma concolor*), find it difficult to survive within urban environments or have been eradicated from many urban areas (Grompper 2002). The urban coyote now replaces the top predators and therefore can influence the food web dynamics.

Green spaces are suitable habitats for coyotes. Park and forested areas are found throughout urban areas and provide the coyotes with protection from the public, as they complete their daily activities and facilitate their survival. These urban wilderness areas have the potential to provide a diverse diet to top predators, such as coyotes and meso-predators, however their populations are controlled by the availability of their resources (Estes et al. 2001). Seasonality and availability of resources can influence the coyote's diet (Gehrt and Riley 2010; Patterson et al. 1998). While many prey resources are found year round in urban wilderness areas, such as squirrels (*Sciurus carolinensis*), Eastern cottontails (*Sylvilagus floridanus*), woodchucks (*Marmota monax*) and small rodents (particularly the *Cricetidae* family), other food options that appeal to coyotes may be present during specific times (Gehrt and Riley 2010), such as migrating waterbirds. Due to limited space and resources, some birds may create nests on the ground, making them easier prey for coyotes. It is expected that the coyote's diet will diversify when

such changes in resource availability occur. As a result coyote movement patterns should reflect their choice in diet.

As one of the most studied carnivores in North America (Gese 2004), the coyote may also be the most misunderstood predator within an urban environment (Gehrt and Riley 2010). Published work often focuses on rural coyote populations, behaviours, movements and habitats (Atwood et al. 2004; Gehrt and Riley 2010; Hernandex and Laundre 2003; Larrucea et al. 2007; Mitchell et al. 2004; Patterson et al. 1999; Prange and Gehrt 2007; Séquin et al. 2003). Urban coyote publications have increased over the last decade as the coyote's habitat and resources expand. Conflict and interaction between coyotes and people is prevalent in urban coyote research (Gese et al. 2012; Gehrt et al. 2013; Grubbs and Krausman, 2009). However, the urban coyote's diet has also been examined (Gehrt 2007; Morey et al. 2007). Few studies have examined their movement throughout a city (Grubbs and Krasman 2009; Way et al. 2004). With the coyote's expansion and increase in sightings in urban environments within the last 20 years (Gehrt 2004), it is inevitable that their prey selection would dominate the urban predator discussion.

The flexibility in the coyote's diet is essential in order to survive in an urban environment. Urban coyote diet analysis has emphasized the diversity of prey items. A study in a nature area by Souther and Wiggers (2012) determined that approximately 73 percent of the coyote's diet consisted of small rodents, insectivores and birds. Vegetation was also present in scat samples (Souther and Wiggers 2012). Gehrt (2004) noted a similar trend in urban coyote diets, but further examined the amount of refuse. Gehrt monitored coyote movements and determined that coyotes were not focussing their movement around the availability of refuse (2004). Instead, coyotes were observed foraging on the fringe of parks and green areas (Gehrt

2004). In Chicago, a study determined that the coyote's diet is dependent on the season and availability (Morey et al. 2007). Throughout the five study sites, the top five food categories (small rodents, deer, plants, cottontails, birds) showed seasonal differences (Morey et al. 2007). As a generalist the coyote's diet will include a variety of prey, which will be dependent on the season. Understanding the relationship between their diet and prey availability and seasonality may help understand the spatial movements on the coyote.

Movement throughout an urban landscape is often restricted due to infrastructure and human-dominated landscapes which cause habitat fragmentation for all species. Research has indicated that whenever possible, a coyote will select natural areas (Morey et al. 2007; Riley et al. 2003). Telemetry studies indicate that the range of an urban coyote is smaller than those in rural areas, presumable due to food availability (Grubbs and Krausman 2009). Grubbs and Krausman also indicated that coyotes avoided areas of high human activity or sought cover in dense vegetation. Way et al. (2004) used telemetry techniques to monitor coyote activity levels and results indicated that coyotes were most active from dusk until dawn. Coyotes were tracked throughout the night, stopping in yards and driveways showing little signs of nervousness, whereas they travelled quickly throughout the same areas during the day (Way et al. 2004). Way et al. emphasized the importance of natural areas and corridors for foraging and protection.

I used a mixed method approach to examine the relationship between coyotes and resources within a protected area in Toronto. I collected data from camera traps and analyzed scat to draw conclusions of the coyote's movement and resource selection through a year. Both of these techniques are considered non-invasive (MacKay et al. 2008) and while handling animals is essential in Global Positioning System (GPS) Tracking, it allows the research to observe the precise movements and behaviours of the animal (Turner et al. 2000). I further

analyzed movement patterns by using a GPS collars. These three methods will provide a better understanding of the relationship coyotes have with their surrounding resources dependent on season and availability, while tracking movement to determine patterns based on dietary resources.

STUDY AREA

Tommy Thompson Park [TTP], also known as the Leslie Street Spit, is a five kilometre landmass that extends into Lake Ontario. TTP covers approximately half of the 500 hectares and is protected and managed by the Toronto and Region Conservation Authority (TRCA; Fig. 1). The remaining area of the split is an active industrial zone where industries can dump their clean fill and construction waste, monitored by the Toronto Port Authority. Intended to be a breakwater for the Toronto Harbour (Friends of the Spit 2013), the spit has been transformed into an Ecologically Sensitive Area, with one of the largest natural habitats along the Toronto waterfront (TRCA 2014a). Despite being only open on the weekends due to its active construction status, TTP has over 100,000 visitors annually (TRCA 2014b).

The park has a wide variety of vegetation cover, including meadows, forests, shorelines, sand dunes and wetlands (TRCA 1992). Three ponds, separated by dams are found in the centre of the spit, with the main roadway and pedestrian paths surrounding them. Four sub-peninsulas on the west side of the park are forested, however due to an increase in the double–crested cormorant (*Phalacrocorax auritus*) populations both Peninsula A and B have experienced tree mortality (Taylor et al. 2012).

Due to the ecologically sensitive species and status as an Urban Wilderness, TTP restricts pets in entering the park. The park is known for its migratory bird populations, and has Important Bird Area status due to large colonies of ground-nesting waterbirds: double-crested cormorants

and ring-billed gulls *(Larus delawarensis;* Wilson et al. 2001). Gulls nest on the ground (Peninsulas A and B), cormorants nest both on the ground (Peninsula B) and in trees (Peninsulas B, C) (Taylor et al. 2012). In 2011, 11,374 pairs of cormorants were using the TTP (40% were ground nesting), while approximately 30,000 gulls nested on Peninsulas A and B (Foster and Fraser 2013). There are also 316 species of birds both migratory and residents that have been spotted at the park (Wilson et al. 2001). TTP is also home to a variety of plants, reptiles and mammals. The TRCA has noted records of a variety of mammals including: beaver (*Castor canadensis*); American mink (*Mustela vison*); muskrat (*Ondatra zibenthicus*); raccoon (*Procyon lotor*); Eastern cottontail; woodchuck/groundhog; deer mouse (*Peromyscus maniculatus*); white-footed mouse (*Peromyscus leucopus*); meadow vole (*Microtus pennsylvanicus*); Virginia opossum (*Didelphis virginiana*); and, Eastern gray squirrel (TRCA 2014c).

METHODS

I used three different approaches to explore coyote diet/habitat use at the park: camera traps, GPS tracking and scat surveying.

Camera Traps

I used opportunistic data from camera traps (Cuddleback Infared set on motion triggered, 30 sec intervals) to determine the movements of coyotes in relation to the presence or absence of colonial waterbirds (Fig. 1). Throughout three field seasons (2010, 2011, 2013; while the cameras were run in 2012, following the death of the breeding male in the fall of 2011 [see below] coyotes were not present at TTP in 2012 [G.S. Fraser personal observation] and therefore those data were excluded from the analysis), cameras were deployed at three different stations on Peninsula C 300 metres apart (while cormorants nested in trees on this peninsula (stations 1 and 2), there were regularly birds on the ground collecting nest material, or chicks that have fallen

out of nests; G.S. Fraser personal observation). The cameras were deployed for approximately 35 days during the waterbird Nesting Season (April 25-May 29, 2010; May 4-June 7, 2011; May 8-June 13, 2013) and Post Nesting Season (September 20-October 24, 2010; September 21-October 18, 2011; September 20-October 25, 2013). The cameras were originally used for a raccoon study; coyote presence was determined from the images collected.

The spacing intervals of the camera stations were based on the minimal home range of raccoons for the original study (Chen 2012). Cameras were installed approximately 0.5 metres from the ground, a recommended height to ensure visibility of small and medium sized animals, including coyotes (Gompper et al. 2006). No lures or bait was used. To ensure that coyotes were not counted twice in one crossing, a new crossing was arbitrarily counted after 30 minutes from the initial timed photograph, as recommended by Kelly and Holub (2008). The amount of crossings could then be calculated to determine the coyote's reliance on seasonal resources. In 2010 there was one camera per station. In 2011 and 2013 there were two cameras per station. Cameras were checked approximately once a week to retrieve photos and ensure the cameras were functioning.

Using a week as the sampling interval, percent occupancy was calculated by dividing the total number of camera sites by the number of sites where the coyotes were photographed (MacKenzie and Nichols 2004). A weekly average per station was calculated for the Nesting Season (hereinafter "Spring") and the Post Nesting Season (hereinafter "Fall") and compared amongst years using a Kruskal-Wallis test. Occupancy percentages were arcsine-transformed prior to analysis (Purdy et al. 2004). I predicted that coyote occupancy would be lower during the Fall for camera stations 1 and 2. Due to station 3's position and distance from the nest site, the coyote occupancy should be maintained throughout all seasons.

GPS Tracking

On May 31, 2011 a breeding male at TTP was trapped and fitted with a Lotek Wildcell SG GPS-enabled radiocollar (by Ontario Ministry of Natural Resources and Forestry [OMNRF] following their animal care protocol). He was captured using a Victor #3 Softcatch foot-hold trap and using a mixture of ketamine HCL (5mg/kg) and meteomidine HCL (50μg/kg), was chemically immobilized. For six months (May 31–November 29) the collar recorded the coordinates of the coyote's position every three hours. Approximately twice a month it would record the location every 15 minutes for 24 hours, providing a detailed map of the coyote's movements. The coyote died in November (presumed to have been struck by a vehicle).

Collar data were transferred into ArcMap 10.1, GIS analysis software. Locations were divided into weeks and months to determine the route travelled and movements with respect to food resources (e.g., nesting waterbirds). The finer scale data (i.e., 15 minute intervals for 24-hours twice per month) were analyzed separately. Movements on and off the sub-peninsulas where nesting waterbirds congregate (Fig. 1), as well as movements outside the park were monitored. Point-analysis was used to determine potential routes and time spent in specific areas (Rodgers and Kie 2011).

Scat Surveying

Scat samples were opportunistically collected from May 2013 to September 2014 within the TTP boundaries. Each sample was labelled with date and location and placed in a clean sealable plastic bag. Each sample was then stored in a -20°C freezer until processing to eliminate potential parasites (Bacon et al. 2011). Single scats were then placed in pieces of nylon stockings with an identification marker and tied at both ends (Klare et al. 2011), then placed in a boiling pot of water and soaked for approximately 30 minutes to eliminate outstanding parasites

(Patterson et al. 1998). Samples were then washed thoroughly with clean water and left in the sun to dry (Klare et al. 2011) for two to three days, flipping samples every half day to ensure proper airflow.

Once dry, five to ten hair (or feathers if present) samples were randomly selected from each sample for cuticular analysis (Bacon et al. 2011). Hairs were imprinted onto slides using hair spray, then examined under a compound microscope. Adorjan and Kolensky's (1969) method of analysis and identification of cuticular scale patterns were followed. Due to similarities in scale patterns amongst the mice and vole family, these species were grouped under the small rodent category. Percentages of the identified hair and bone sample's volume were then recorded for each scat and rounded to the nearest 5% (Patterson et al. 1998). Where trace amounts of a sample existed, they were recorded to 5% (Patterson et al. 1998). Species were counted if their hairs consisted over 20% of the total scat sample. Trace amounts were not tabulated, however their presence was noted**.**

RESULTS

Camera Traps

Camera traps captured a wide variety of mammalian species: coyotes, raccoons, woodchucks/groundhogs, rabbits, mice/voles, opossums, beavers, squirrels and minks. Coyotes were captured on camera during both the Spring and Fall of 2010 and 2013 and for Spring only for 2011. Cameras throughout the five seasons captured 445 animal crossings photographs of which 42 were coyotes. Spring 2010 recorded the most coyote crossings; 11 coyote photos of 46 total photographs (24%). Fall 2010 recorded the least coyote crossings; four of 53 total photographs (8%). Spring 2011 had the lowest percentage of coyote crossings relative to the amount of animal photographs (5%; seven coyote photos of a total 147). Nine coyotes were

captured on camera in Spring 2013, with a total of 66 animal crossings recorded (14%). Fall 2013 captured 11 coyote crossings from 133 photographs (8%).

Although no camera stations reported 100% occupancy, Station 1 in Spring 2010 and Station 3 in Spring 2013 recorded the most occupancy (Table 1). Station 2 recorded the least occupancy consistently throughout all seasons, whereas Station 1 was the most consistent. Both stations 1 and 3 recorded at least one coyote crossing throughout their 5-week deployment in both Spring and Fall. Station 2 did not record any crossings in Fall 2010, Fall 2011 and Spring 2013. A few Fall data may be missing in 2010 (1 week of data for Station 1), due to a stolen camera. One image captured on May 26, 2010 was of a coyote (likely the male prior to being GPS collared in 2011) carrying an egg (Fig. 2); no other images showed prey.

There was no difference between year and station ($H=3.09$, $df=2$, $P=0.21$; $H=3.09$, $df=2$, $P=0.21$) and insufficient data for seasons for the Kruskal-Wallis test.

GPS Tracking

Activity and movements were monitored for one coyote for 6 months (June to November 2011). During this time 2,415 location coordinates should have been recorded, however due to various issues (i.e. weather, vegetation cover, industrialized landscape) only 2,230 positions were documented.

The coyote was tracked outside park boundaries 1,211 of the 2,230 (53%) documented GPS positions and it varied over the months sampled (June 140 of 476 points [29%]; July 156 of 402 points [39%]; August 260 of 330 points [79%]; September 330 of 490 points [67%];October, 133 of 263 points [51%]; and November 192 of 355 points [54%]). The coyote was tracked onto the sub-peninsulas four of the six months (June, July, August and November). Peninsula A, B and C were visited often by the coyote (19 times in June, 32 in July and 7 in August, for a 4%,

8% and 2% visitation during those months respectively; Table 3). Peninsula B had the highest visits in July (17 GPS points), while Peninsula D was only visited once (during November).

Fourteen 24-hour periods had between 41 and 104 location points. There should only be 96 15-minute location points, however one 24-hour period was extended by an extra 2 hours. The coyote left the park twelve of the fourteen 24-hour periods (did not leave once in June and once in July [Fig. 3]) and was tracked outside the park between 2 to 96 times (Table 2).

Scat Analysis

In total, 66 scat samples were collected, however two samples were not included in the results due to lack of sufficient hair. Of the 66 samples, 36 (55%) were collected between the months of April and July, while the other 30 (45%) were collected between August and March. I detected ten different prey items in the 64 scat samples analyzed. Nine of the 64 scat samples (14%) had more than one prey item.

Eastern cottontails represented 24% of the prey items identified. Woodchuck/groundhogs comprised 17% of the prey species. Small rodents (mostly deer mice, white-footed mice and meadow voles) represented 14% of the prey species. Eastern gray squirrels comprised 11% of the prey items identified. Birds (determined by the presence of feathers) and the European hare each represented 10% of the prey items identified. Muskrats comprised 9% of the prey species. A Virginia opossum and cat each represented 2% of the prey species. Coyote hair represented 1% of all hairs identified in the scat (Table 4). One raccoon hair was identified, however, it was not included due to its singular presence.

Other items found in the prey included grass and plant materials, rocks and bones. Bones of prey animals were detected in 42 of the 64 scat samples (65%). The two scat samples that lacked sufficient hair samples did contain recognizable amounts of grass and plant material and

rocks. It is possible that these two samples could have been goose droppings however coyotes are known to have consumed plant material (Morey et al. 2007). These two samples were added to the total for these two categories. Grasses and plant materials were identified in 23 of 66 samples (35%), and rocks were detected 25 of 66 samples (38%).

DISCUSSION

Coyotes are capable of adapting to urban and suburban life; locating most resources in secluded forested areas (Gehrt, 2007; Gese et al. 2012). Although tracking coyotes is difficult (Way et al. 2009), determining their movements in search of dietary resources will help understand the dynamic that occurred at TTP. The limited size of TTP does not support multiple breeding coyotes (GS Fraser personal observation).

Camera Trapping

I predicted that coyote presence, as measured by percent occupancy, would be lower in the Fall compared to the Spring. When examining the average percent occupancy across stations and years, Spring had higher presence than the Fall, which corresponds to the nesting season of the colonial waterbirds. This could indicate a preference towards the birds as a prey resource because of their availability. Patterson et al. (1998) determined that coyotes will prey switch depending on the prey diversity, abundance and vulnerability. However, with the limited number of years, we were unable to statistically confirm this trend. Unlike mammalian hair, feathers are not as well preserved after digestion, as they are highly fragmented, similar to egg shells (Reynolds and Aebischer 1991). Although feather quills persist, they may not be passed in the same scat as their feather fragments (Reynolds and Aebischer 1991). As a result, bird consumption and presence in scat samples may be underestimated (Reynolds and Aebischer 1991).

Difference in occupancy between stations was evident, but not statistically significant. Despite being furthest from the main trail areas, camera station 1 (located towards the tip of the Peninsula C) had the highest occupancy. Waterbirds were present in this area, however they were also present around camera station 2. Coyotes have been known to select routes that avoid cameras if they are aware of their presence (Séquin et al. 2003). This could explain the low occupancy for this station regardless of its placement between station 1 and station 3; however due to tree mortality the low occupancy for Station 2 may also be explained by downed trees resulting in difficult terrain. Station 1 on Peninsula C was easily accessed by a sandy beach running the length of the peninsula.

Due to its location at the bottom of Peninsula C, camera Station 3 recorded coyote occupancy throughout both seasons and all years. This station was not located in a nesting area but was near (20 m) one of the main roads in the park. Coyotes presence was likely captured due to the location being a thorough fare between sub-peninsulas. Ideally, increasing the distance between camera stations and dispersing them throughout Peninsulas A and B would provide more insight into the coyote's distribution and abundance in different seasons (Kays and Slauson 2008). Using a grid model, one camera every 0.25 km^2 is recommended (Larrucea et al. 2007; Séquin et al. 2003) or every 500 metres for line transects (Grompper et al. 2006).

GPS Tracking

Home ranges vary for coyotes in urban areas due to the fragmentation of habitat and available resources, and can vary seasonably (Grubbs and Krausman 2009). GPS tracking showed that considerable time was spent off-site in surrounding industrial and parkland areas (Fig. 4). Sub-peninsula activity was highest during June and July, when waterbirds were present and during those months the coyote spent the least amount of time outside the park boundaries,

suggesting that it was attracted by food availability in the park. Souther and Wiggers (2012) noted that birds are an important prey item to coyotes and the presence on the sub-peninsulas during nesting season suggests that this male coyote was also searching for birds as a potential food source. Over the years sampled coyotes were observed in the waterbird colonies when eggs or young chicks were available (G.S. Fraser personal observation).

The 15-minute location points provided valuable insight to the coyote's movement during the 24-hour time period. Atwood et al. (2004) determined that coyotes can travel between eight to 11 kilometres a day in urban areas, and knowing the fine details of the coyote's movement is beneficial. Collecting a position every three hours does not reflect the true movement of the coyote, as accessed areas can be missed during the three hours. Bacon et al. (2011) suggest locations should be transmitted once every hour. Unfortunately the more frequently the GPS tracks the position of the coyote; the faster the collar battery drains. By choosing a three-hour period to transmit the GPS positions, it was hoped that approximate movement could be determined to provide a general overview of the route travelled.

The GPS data showed that Peninsula D was visited once throughout the six months by the coyote and that it occurred in November. This avoidance of the area could be due to its proximity to the marina (which can be accessed at all times and although people were there at night, by November traffic would have been reduced (G.S. Fraser unpublished data)) and a bird banding/Ecological Research station (located North of Peninsula D), thus it is the area with the highest amount of human activity. Atwood et al. (2004) suggest that coyotes purposefully avoid exposure to humans and their development which likely explains the pattern observed. Given the limitation of the logging interval of the GPS collar it is possible that the coyote did access Peninsula D more. Coyote scat samples were collected in the area of Peninsula D, but all during

the “off-season” (late-September and early-April) for boaters. Understanding if resident coyotes are avoiding this area would require more GPS data on more individuals at TTP.

A significant amount of GPS coordinates were not recorded during the day, as scheduled. Grubbs and Krausman (2009) had similar issues and attributed it to dense vegetation cover in which the coyotes would seek cover and protection. It is not always possible to acquire sufficient satellites to calculate the precise location.

Scat Analysis

Coyotes are generalist predators and have the ability to change their prey selection according to their abundance and availability (Patterson et al. 1999). I hypothesized that during the Spring; the coyote scat would show an increase in avian samples. This would indicate that the coyotes were switching their prey to an abundant resource and based on prior studies would not be an unexpected result. Souther and Wiggers (2012) found that avian species comprised about 13% of the coyote’s diet. It is suggested that coyotes would most likely feed on young, wounded, sick or dead birds (Meinzer et al. 1975). Morey et al. (2007) noted the importance of birds in the coyote’s diet from an increase between November to March in Chicago. Although similar climatically, this study did not notice a strong seasonal difference between the nesting season and the rest of the year, however, given the scale of the prey resource coyotes may cache eggs which would not be detected in the scat samples (Meinzer et al. 1975). Five samples contained birds in May to July, while four were collected between December and January. This suggests that given the opportunity and availability of the resource the coyotes would hunt birds in any season.

Cottontails and woodchucks were a staple prey item in the coyote’s diet. Woodchucks were only present in scat samples from March to November, as a result of hibernation during the

winter months. Similarly the muskrat was also present in samples from May to September. Although not a hibernating animal, they are less active in the winter and seek safety in their lodges. When these prey items were not present, the coyote took to consuming cottontails as they were always available. Similar to Morey et al. (2007), there was a decrease in cottontail consumption during the summer months. They attributed the decrease in consumption to vegetation growth and protective covering, thereby making them less visible (Morey et al. 2007).

The most diverse prey season was from April to July, as a result of an increase in activity from prey resources. Morey et al. (2007) research indicated that this is not uncommon was summer months increase activity amongst animals, particularly small rodents; this makes them particularly vulnerable to coyotes.

Studies have shown that human associated food items appear in coyote scat samples (Gehrt 2007), especially in research that has occurred on the west side of the continent (Morey et al. 2007). Gehrt (2007) determined that despite the availability of anthropogenic food sources coyotes were not altering their movements around refuse areas. Surrounded by industrial buildings and park lands, the TTP coyotes would not have as much access to refuse other than from park patrons. As a result no refuse was recorded in any of the scat samples. Morey et al. (2007) also suggest that the high diversity in prey items in developed areas may explain the low amount of human associated refuse, which would further reduce human-coyote conflict. The lack of refuse and diversity of prey items within TTP would indicate that the possibility for human-coyote conflicts are minimal.

Management Implications

The relationship between a predator and their resources is important to understand in any environment, especially if it is urbanized. As a top predator in an urban environment, the

coyote's relationship with food resources is essential in determining their management and future. Fieldwork is crucial in determining how the coyotes move throughout the area and access food. GPS collars are costly and invasive, as it requires handling the animal, however they provide detailed information of the coyote's movement. They allow researchers to follow the coyote from a distance without disrupting the natural movement of the coyote. Diet analysis through scat samples is a relatively inexpensive, non-invasive way to determine what the coyotes are eating and where they have been. However correctly identifying scat samples and hairs within the samples will depend on the technician's ability to do so (Bacon et al. 2011). Camera traps are an excellent method to determine percent occupancy and abundance of animals, not just coyotes, provided the data is sufficient (Nagy et al. 2012). Managers should consider employing scat analysis and camera trapping in areas where coyotes are present. Understanding coyotes within specific urban settings will help determine their resource needs and provide insight into their influence in the ecosystem dynamics.

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FIGURES AND TABLES

Figure 1: Leslie Street Spit and Tommy Thompson Park. Three camera stations are illustrated on peninsula C.

Figure 2: Camera traps captured a coyote carrying an egg in its mouth on May 22, 2010.

Figure 3: GPS collar points on July 11th, 2011 indicated that the coyote stayed within the Leslie Street Spit. The collar provided a location every 15 minutes during the 24-hours. Ground nesting cormorants and gulls were present on peninsulas A and B.

Figure 4: GPS collar points from May 31, 2011 to November 29, 2011. This includes both 3-hour and 15-minute locations.

Table 1*:* Camera trap station's percent occupancy of coyotes at Tommy Thompson Park, Toronto Ontario.

Year	Season	Station	Average Percent Occupancy; SD= ±20.3563	ARCSINE
2010	Spring	1	60	0.643501
		2	20	0.201358
		3	40	0.411517
	Fall	1	20	0.201358
		2	0	0
		3	40	0.411517
2011	Spring	1	40	0.411517
		2	20	0.201358
		3	20	0.201358
	Fall	1	0	0
		2	0	0
		3	0	0
2013[a]	Spring	1	40	0.411517
		2	0	0
		3	60	0.643501
	Fall	1	40	0.411517
		2	40	0.411517
		3	20	0.201358

[a] Coyotes were not present at Tommy Thompson Park in 2012.

Table 2: Amount and percentages of GPS collar location points for one male coyote found outside of the park boundaries during the 24-hour, 15-minute location period (n = 14 sessions recorded) at Tommy Thompson Park, Toronto Ontario.

	Date	No. of locations	No. of off-site locations	Percentage off-Site
June	6-7	91	0	0
	15-16	91	9	10
	28-29	96	74	77
July	11-12	96	0	0
	24-25	96	96	100
August	6-7	96	76	79
	19-20	96	74	77
September	1-3	104	52	50
	14-15	96	89	93
	27-28	96	74	77
October	11-12	54	2	4
	23-24	41	36	88
November	5-6	92	45	49
	18-19	65	65	100
AVERAGE		81	49	54

Table 3: Amount of GPS collar location points for one male coyote found on the sub-peninsulas at Tommy Thompson Park, Toronto Ontario. Total percentages were calculated from total monthly location points. June and July were months where waterbirds are present nesting on the ground (Peninsulas A and B); June, July and August have cormorants nesting in trees (Peninsulas B and C).

	June		July		August		November	
Month Total	476		402		330		355	
	#	%	#	%	#	%	#	%
Peninsula A	8	47	7	22	0	0	0	0
Peninsula B	7	41	17	53	6	86	0	0
Peninsula C	2	12	8	25	1	14	1	50
Peninsula D	0	0	0	0	0	0	1	50
TOTAL	17	4%	32	8%	7	2%	2	0.6%

Table 4: Number of species identified in coyote scat samples, organized by the month of which the scat samples was collected at Tommy Thompson Park, Toronto Ontario.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Feathers	2				1	1	2					1	7
Cottontail	2	3	3	4	4							1	17
European Hare	2			1	1					2		1	7
Woodchuck/ Groundhog			1	1	1	5	1	1		1	1		12
Muskrat					1	1	3		1				6
Squirrel			2	1	2	1			1			1	8
Small Rodents	1	3		1	2	1	1		1				10
Cat					1								1
Opossum					1								1