Understanding Urban White-Tailed Deer (*Odocoileus virginianus*) Movement and Related Social and Ecological Considerations for Management

by

Erin C. McCance

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfillment of the requirements of the degree of

DOCTOR OF PHILOSPHY

Department of Environment and Geography

University of Manitoba

Winnipeg, Manitoba, R3T 2N2

ABSTRACT

White-tailed deer (WTD) (*Odocoileus virginianus*) were studied within the Greater Winnipeg Area (GWA) to investigate urban deer home range size, habitat use, and seasonal movement patterns. A comparative analysis was also completed in Riding Mountain National Park (RMNP) in order to assess the similarities and differences between urban and rural deer spatial and temporal movement patterns. The study revealed differences in the spatial land use patterns of these two cohorts with substantially smaller urban WTD monthly and seasonal home range sizes than in RMNP. Building on the findings derived from the animal-borne locational data, an investigation into the human social dynamics associated with the urban deer herd indicated that human behavior heavily influences urban deer movement. Using a critical case study approach, the research investigated the wildlife value orientations and the emotional dispositions associated with the human behavior of intentionally supplying artificial food sources for deer. The spatial and temporal occurrences of urban deer-vehicle collisions (DVCs) and the factors associated with high risk DVC roadways were not random, and human social behavior is correlated to the frequency and location of DVC occurrences in the GWA. This research identifies management strategies to successfully mitigate human-wildlife conflict and the associated human-human conflict within the GWA, as well as the need for, and challenges associated with, an integrated approach to urban wildlife management.

ACKNOWLEDGMENTS

This research would not have been possible without the financial and in-kind support received from Manitoba Hydro, Parks Canada, Manitoba Conservation and Water Stewardship, the Mitacs Accelerate Program, and the University of Manitoba.

There were numerous individuals who offered their support and guidance throughout the course of this research, to whom I am incredibly grateful. I am thankful to Fiona Scurrah, Trevor Barker, and James Matthewson at Manitoba Hydro who offered their tutelage, ongoing direction, and essential assistance during meetings and on the ground with deer trapping efforts.

I thank Bill Elliott, Ken Cudmore, and all of the staff at FortWhyte Alive, who were continually supportive with respect to the deer collaring activities and who invested their ongoing interest and promotion of the research.

I am very grateful to Dr. Chris Enright at the Assiniboine Park Zoo for sharing his expertise and for his support during all deer collaring endeavors.

During the course of this research, I had the great fortune of meeting many wonderful Greater Winnipeg Area residents who assisted with research efforts. Most notably, I am immensely grateful to Pat and Nancy Caldwell and Del and Jack Matheson for their overwhelming hospitality and generosity. Most of all, however, I am thankful for their friendship.

I am thankful to Bob and Patty Simpson at Dauphin Air Services, for their contribution to the research during capture efforts and flying to locate collars over the past several years.

I am deeply indebted to Paul Tarleton and the Wildlife Lab team of Riding Mountain National Park, specifically Doug Bergeson, Tim Sallows, Ken Kingdon, Roxanne Grzela, and Ross Robinson. I am very thankful of their efforts and dedication to the deer collaring activities both on the ground and aerially, including capture, collar re-locations, and the retrieval of drop collars. This study would not have been possible without their generosity and the continued use of their traps and supplies. Over and above, I am thankful for their welcoming nature providing me the opportunity to experience and learn new things. I take away an appreciation of their respect for wildlife and their commitment and enthusiasm for the work they do. I am especially thankful to Tim Sallows whose assistance with the deer trapping undertakings was crucial to the success of this research. I am extremely grateful for Tim's commitment, his determination to assist me in persevering through difficult situations, and for all of the knowledge he shared with me.

There are many staff with Manitoba Conservation and Water Stewardship that I am very thankful to. I am appreciative of all of the efforts and support of Ken Rebizant, Herman Dettman, Rob Bruce, Cam Meukon, and Brian Joynt especially during the deer capture activities, numerous planning meetings, and offering their advice. I appreciate the direction and support of Jack Dubois, Dan Bulloch, and Dr. James Duncan with respect to this research. I am especially grateful to Ken Rebizant and Brian Joynt for their time and effort in seeing me through this process. Their support was instrumental for me during the course of this research. I am very grateful to you both.

I am very thankful to Doug Schindler for his patience and encouragement of my pursuit of this degree. I appreciate your guidance, friendship, and continued belief in my abilities.

I am thankful to my peers and dear friends Jen Syrowitz, Fiona Scurrah, and C-Jae Breiter for their ongoing motivation and support. Thank you to Tim Davis for his patience and tutelage over the last several years.

I am extremely grateful to my academic advisory committee, Dr. Michael Campbell, Dr. Rick Riewe, and Dr. David Walker. I have learned a significant amount from each of you and I appreciate all of your support and direction. I am especially grateful to my primary advisor Dr. Rick Baydack. I am extremely lucky to have had the good fortune to work with you and appreciate all the knowledge you have shared with me, both with respect to this research and beyond. I am forever grateful for this opportunity.

It is difficult to articulate my gratitude to my parents, husband, and son for their commitment and encouragement in seeing my through this process. Thank you to my dad for his love and continued passion for the great outdoors. I am immeasurably grateful to my mother whose motivation and vision led me here. She inspires,

challenges, and teaches me every day. I aspire to be a successful scholar of even a fraction of my mother's distinguished caliber. To my husband and son, words cannot express my appreciation for all of your sacrifices, patience, and support in seeing me through this process. I adore you both and look forward to our adventures that lie ahead!

DEDICATION

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 Theory

During the latter half of the twentieth century, human population growth and urbanization resulted in significant changes in human occupancy of the landscape, re-shaping the global footprint, and creating new ecological spaces (Adams & Lindsey 2010). Comprised of "enhanced" ecosystems and defined by predator/prey imbalances (Philo 1998), these newly modified spaces create unique opportunities for generalist wildlife species populations to thrive and reach record high numbers (Adams et al. 2006; Sterba 2012). Although these human induced land use changes are relatively recent, they are occurring at a rapid rate, leaving humans and wildlife to compete, more than ever before, for available space and resources (Madden 2004). Ecologists have primarily studied species populations and communities in non-urban environments and have largely avoided the urbanized world (Alberti 2008). For many species, urban environments offer numerous benefits and although human development has certainly encroached on wildlife habitats, many wildlife species have realized benefits within urban environments and live out their lives within urban spaces (Sterba 2012), defining a new way of living for both humans and wildlife. The urban-wildland boundary has now become increasingly obscure (Gullo et al. 1998). Within these 'city' spaces, urbanites have complex and shifting views on how to adapt to their new 'neighbours' (Decker et al. 2001). The resulting dynamics between humans and wildlife have never been more "confused, complicated, and conflicted" (Sterba 2012). Managers called upon to reduce human-wildlife conflict in urban areas find themselves within an arena of competing interests as they face the ecological and social dynamics associated with urban wildlife management (Adams & Lindsey 2010).

Using a growing urban white-tailed deer (WTD) (*Odocoileus virginianus*) population within the Greater Winnipeg Area (GWA) as a case in point, this dissertation explores urban WTD movement, human-deer conflict, and the social and ecological considerations necessary for urban deer management. This dissertation also investigates deer movement data acquired from deer residing in Riding Mountain National Park (RMNP). RMNP represents larger un-fragmented blocks of habitat characterized by lower human population density. In doing so, a comparative analysis is undertaken to assess the similarities and differences of deer movement within the highly developed metropolitan spaces of the GWA with those of deer residing in the larger un-fragmented blocks of habitat found in RMNP. Of importance to note, RMNP is located at the divergence of three different landscape ecosystems and is representative of diverse vegetation types that differ from the remnant habitat patches that comprise the GWA landscape.

1.1.1 Human Population Growth and Urbanization

The past 60 plus years represent a time when First World societies underwent a transition from rural, agricultural, to urban lifestyles (Adams et al. 2006). Population growth and capitalization, coupled with the influx of people into urban centers, have stretched city limits and created infrastructure in previously natural, undeveloped habitat. Adams et al. (2006) define an urban environment as one that has a large central place and adjacent densely settled census blocks that together have a total population of at least 50,000 people. Human population continues to grow, with the United Nations estimating that the human population of North America, currently 352 million people, will reach 448 million people by 2050 (http://unstats.un.org). Today, roughly 80% of Canadians live in urban/suburban areas (Canadian Education Association web page accessed on March 5, 2008), as do 80% of Americans (Adams et al. 2006; Adams and Lindsey 2010). The growth of the human population is partnered with the mainstream desire for people to reside within urban and suburban spaces (Gillham 2002). Currently there are 20 cities worldwide that have human populations over 20 million people compared to just two cities of this size in the 1950s (Alberti 2008). Regionally, in 40 years between 1950 and 1990, U.S. metropolitan spaces grew from 538,720 km^2 and 84 million people to 1,515,150 km^2 and 193 million people (Alberti 2008). Hand-in-hand with increasing human populations and urbanization are all the associated decisions made with respect to land-development and infrastructure influenced by job markets, real-estate, house-hold preference, highway placement, among other variables (Alberti 2008).

As a result of these human induced inter-related land use changes, the landscape is increasingly shaped by extensive fragmentation of habitat, which is one of this century's most substantial threats to wildlife populations and biodiversity (Wilcox & Murphy 1985; Hilty et al. 2006; Manfredo 2008). Without question, urbanization and its associated development shape the global footprint more than ever before with the earth's ecosystems increasingly influenced by the rate and pattern of urban growth (Alberti 2008).

Presently, many metropolis areas are not defined by a single city center but rather by a series of extended suburban areas, one connecting to another, bleeding out across the landscape, and creating what Gillham defines as "the limitless city" (Gillham 2002). Suburbs are no longer easily defined as low-density residential housing surrounding city centers. The Industrial Revolution changed North America. Cities centered on large-scale factory production developed rapidly and over time, residents within these communities began to realize the negative environmental and social consequences brought on by having large-scale factory production located within city spaces. In response to these polluted, noisy, and dirty city neighborhoods, people gradually retreated to the urban-wildland interface (Gillham 2002; Squires 2002). Suburbs and urban sprawl resulted (Gillham 2002; Squires 2002). In the latter quarter of the twentieth century, suburbs increasingly emerged, stretching out from city centers (Adams & Lindsey 2010).

By the start of the twenty-first century, more people in North America lived and worked in suburbs than in city centers (Gillham 2002).

Cities themselves are some of the most profoundly altered ecosystems on earth (Collins et al. 2000). Despite the emergence of environmentalism, the animal rights movement, and rising concerns with regard to habitat loss and declining biodiversity, urbanization is still occurring at rapid rates (Gullo et al. 1998). Biodiversity is increasingly reduced and as Wilson (1988) argues, the global rate of extinction is substantially higher as the result of human land changes and resource use; he suggests that, should the current rate of biodiversity loss continue, we will experience the most extreme extinction event in the past 65 million years (Wilson 1988). These losses will be devastating for humans as many of our medicines, foods, fibres, and economies are dependent on wild species (Hilty et al. 2006). This is not to mention the impact species loss has on the health and viability of a functioning ecosystem (Beatley 2011). Natural processes such as maintaining air quality, soil production, nutrient cycling, moderating climate, producing fresh water, mitigating pollution, degradation of wastes, and controlling disease and parasites will break down (Hilty et al. 2006). In addition to these losses are those associated with cultural, emotional, and spiritual enrichment these species provide (Hilty et al. 2006). Human demand for resources and our footprint on the land leave many wildlife species struggling with a loss of available habitats (Hilty et al. 2006).

As Jennifer Wolch contends, there is a mainstream theory that urbanization transforms “empty” land through the process of “development” to produce “improved” land, a movement toward the “highest and best use” of space (Wolch 1998). She points out, however, that this transformation is not of “empty” space at all, but of wildlands that are teeming with non-human life. These human induced land use changes result in ecological destruction and a denaturalization of the environment such that the resulting landscapes are characterized by impoverished soil quality, poor drainage, and invasive species. Urban ecology is often comprised of systems that are out of balance as some species are welcome while other species such as predators, considered intolerable, are excluded. Wolch argues that human practices have altered the global environment as never before (Wolch 1998). Wildlife managers, among others, who regard the conversion of these “empty spaces” and overall biodiversity loss as intolerable, must confront the phenomenon of contemporary urbanization. Wildlife management within urban centers should consider biodiversity and species co-existence (Beatley 2011; Wolch 1998). When managing overabundant populations of urban wildlife, however, there are numerous inter-related challenges associated with attempts to manage for biodiversity and ecological integrity within urban spaces.

1.1.2 Spatial Geographies

Coupled with these human induced transformations of the landscape from un-developed to developed spaces are the specific spatial orderings that humans have with respect to animals, situating them as either “in or out of place.” Numerous scholars have now begun to challenge the traditional geographic boundaries humans have established with relation to the “proper” places animals should physically occupy (Emel and Wolch1998; Gullo et al. 1998; Lynn 1998; Brownlow 2000; Jones 2000; Philo & Wilbert 2000; Wolch et al. 2000). These human-constructed spatial orderings of animal geography situate wild animals in relation to space, place, environment, and landscape. Animals in zoos are said to be “in place,” and we have identified boundaries upon which some animals are welcomed to occupy space within our daily lives while others are clearly thought to be “out of place” (Philo & Wilbert 2000). Owain Jones suggests that human and non-human relations are inevitably embedded in the complex spatialities of the world (Jones 2000). Given our current concerns for environmental integrity, environmental ethics, and reconnection with nature, this is a multi-dimensional issue (Calarco 2008). Looking at the relationship between animals and humans, which remains deeply complex and shifting, means a likely range of focus across a number of disciplines (Michaelidou et al. 2002). Farm animals, laboratory animals, wild animals, zoo animals, domestic pet animals, all become defined by cultural space, with humans categorizing animals and situating them as either “in or out of place” (Philo 1998) The invisibility of the individual non-human “other” within dominant systems of ethics is the key factor in determining spatialization boundaries (Jones 2000). As in ethics, so in geography: Jones argues that there is a need to focus on non-human geographies as little-to-no attention is given to wildlife (Jones 2000). More than ever before, however, scholars are beginning to deconstruct these spatial orderings and challenging the wild/domestic dichotomy (Clement 2007), along with conventional notions of inclusion and exclusion (Philo 1998). These investigations into human-animal relations have given rise to new terms of reference such as anthrozoology, zoopolis (Emel & Wolch 1998), zoontologies (Wolfe 2008), zoographies (Calarco 2008) and to the study of urban animal ecology. Given the rapid rate of human population growth and urbanization that occurred in the twentieth century, the importance of entertaining the notion of "letting animals back in" (Emel & Wolch 1998), is becoming apparent, this along with opening ourselves to the idea of urban "shared spaces" designed for species co-existence (Emel & Wolch 1998; Gullo et al. 1998; Jones 2000; Philo & Wilbert 2000). It is becoming increasingly critical for urban spaces to be designed for the co-existence of both human and non-human species (Beatly 2011). In aiming for this, however, wildlife management, in this new urban arena, must lend itself to the process of articulating management objectives and actions that consider perspectives across multiple disciplines and involve stakeholders at all levels of management action (Michaelidou et al. 2002). Such considerations have implications for "ecological" and "social" carrying capacity. Urban ecosystems that are "out of balance" due to the human exclusion of predatory species function differently and as such, face challenges when those species populations that we consider to be tolerable grow and become overpopulated.

1.1.3 Ecological Carrying Capacity

Traditionally, ecological carrying capacity and biological carrying capacity have been defined and translated into management objectives and actions that do not involve the complexities and multi-disciplinary perspectives that inform the field today. Wildlife management does not have an extensive history in metropolitan areas for the reason that prior to the mid-twentieth century, North America was predominately a rural society (Adams & Lindsay 2010). In this context, wildlife management models were constructed with a rural landscape in mind. For example, an overabundant WTD population in a given area, devoid of high human population density, would suggest a reduction in deer population size as a viable solution. Today, different resources and modification of limiting factors influence ecological carrying capacity making it far more difficult to measure. Contemporary wildlife management solutions encompass a myriad of considerations (Michaelidou et al. 2002). Several factors deserve mention, including: spatial geographies, human population growth, urbanization, economics, land use planning, urban habitats and ecological function, unnatural food supplies, overabundance, and zoononses (Philo 1998; Wilson 1998; Gillham 2002; Hilty et al. 2006; Alberti 2008; Manfredo 2008; Adams & Lindsay 2010; Beatley 2011). Ecological carrying capacity has been defined as the maximum population size of a given species that an area can support without damaging the area or reducing its future capacity to support the species (Hanley et al. 1999); however, the term carrying capacity itself, while widely used, has been defined in different ways and remains limited and vague (McNab 1985; Buckley 1999; Del Monte-Luna et al. 2004). Detection thresholds of species impacts on the ecosystem can be variable. Depending on the parameter measured and sampling techniques used, and given the complexity of ecosystem function, the practical applications of the detection of impact can be difficult to achieve (Buckley 1999). Urbanization changes natural habitats and species composition, alters hydrological systems, and modifies energy flow and nutrient cycling (Alberti 2008). Therefore, detection of thresholds of species impacts on the ecosystem is even more challenging in urban environments where habitats are "out of balance," highly modified, manipulated, and manicured.

1.1.4 Social Carrying Capacity

More than ever before in recorded history, public concern and awareness for the protection of the natural environment and animal welfare is on the rise (Beckoff 2010; Emel & Wolch 1998). Public values toward wildlife shifted in the latter portion of the twentieth century (Manfredo et al. 2003). Wildlife management in the twenty first century faces the difficult task of addressing, and assessing, the numerous and diverse values and beliefs of these newly introduced stakeholders (Kellert 1996; Herda-Rapp & Goedeke 2005; Manfredo 2008). As the wild-urban interface continues to blur, human-wildlife interaction is increasing (Madden 2004; Herda-Rapp & Goedeke 2005; Manfredo 2008). Fundamental to wildlife management today is this highly fluid public opinion on how animals, including those categorized as problem animals, should be treated (Decker et al. 2001).

The concept of wildlife social (cultural) carrying capacity is defined as the maximum wildlife population that a society will tolerate within a given area (Decker & Purdy 1988; Riley et al. 2002). Social carrying capacity is difficult to determine since it is based on a variety of views of a large number of stakeholders. Decker and Purdy refer to the understanding of how human beliefs and preferences affect decisions on the management of wildlife populations as wildlife acceptance capacity (WAC) (Decker & Purdy 1988; Riley et al. 2002). The WAC concept represents the maximum wildlife population level in an area that is acceptable to people. The WAC concept is asymmetric, given wildlife acceptance will be different for different people. What makes WAC even more complex is that the threshold of acceptance is not static. Stakeholders' acceptance of wildlife population size may change. Stakeholders often do not see eye-to-eye on the acceptable wildlife population size or on the course of management action that should be taken to alleviate the conflicts (Decker et al. 2001).

Pierce et al. explain that human dimensions research draws from the theories and methods of social science disciplines and that cognitive and motivational approaches are used extensively in human dimensions research. The cognitive hierarchy describes the process of human values and their influence on human behavior (Pierce et al. 2001). Cognitive approaches examine concepts such as values, attitudes, and norms, essentially investigating the process that leads from human thought through to human action, and in doing so, provides managers with insights on how they may predict human behavior (Manfredo 2008). Understanding motivational approaches helps managers better understand human behavior.

Individual attitudes and social or normative influences shape an individual's behavioral intentions (Manfredo 2008). In essence, attitudes and normative influences determine how he or she will behave in a specific situation. Therefore, an attitude, is an individual's evaluation of a specific behavior, either good or bad. Manfredo (2008) defines strong attitudes as stable and resistant to change. Strong attitudes influence how people evaluate and process information and guides their behavior (Manfredo 2008).

With recognition of the importance of including human dimensions as critical to the study of plant and animal communities, comes an appreciation of the need for further understanding of the limitations of what Thomas Heberlein defines as the "cognitive fix" (Heberlein 2012). The "cognitive fix" pertains to the notion that human attitudes are amendable to quick change. In drawing on both theory and practice, Heberlein argues that human values and attitudes are deeply rooted and that societal change of attitudes often takes decades (Heberlein 2012). In light of this, Heberlein argues management should consider the "structural fix" which can work consistently with public attitudes and theories of communication and persuasion by changing the structure or context of the situation to influence human behavior. Theories of communication and persuasion use carefully constructed messages aimed at an individual's salient beliefs and values to alter or reinforce a person's behavior (Brown et al. 2010). Therefore, while the understanding of human attitudes is essential to guide the "structural fix" (often management associated with financial penalties/benefits), it is done with the recognition that an attempt to change human behavior by changing human attitudes through educational programs and the "cognitive fix" alone, is often, in and of itself, unsuccessful (Heberlein 2012).

Research conducted by Manfredo et al. (Manfredo et al. 2003; Manfredo 2008) suggests that increasing affluence, education, and urbanization have resulted in a shift in wildlife values from a traditional utilitarian focus to a protection-oriented focus with respect to wildlife. This societal shift suggests that traditional uses and management of wildlife may no longer be preferred by the majority of urbanites (Kellert 1996). This presents challenges for wildlife managers called upon to reduce human-wildlife conflict and manage urban wildlife populations (Decker et al. 2001). The protectionist orientation with regard to wildlife may be connected to the growing non-consumptive interests in wildlife (Manfredo 2008). At the same time, urbanites spending considerable time and money attracting wildlife to their property to increase their connectivity to the natural world and to increase wildlife viewing opportunities may quickly become aware of some of the pitfalls that accompany living in close proximity to wildlife (Conover 1997). Attracting wildlife can lead to property damage, vehicle accidents, and significant human health and safety concerns (Conover 1995; Conover 1997; McCullough et al. 1997; Conover 2002).

1.1.5 Human-Wildlife Conflict

As urban residents create backyard islands of habitat in an attempt to imitate nature and draw in wildlife, often in alarming numbers, the degree to which the urban ecological system is compromised becomes apparent (Adams & Lindsay 2010; Sterba 2012). Generalist species thrive in these urban environments, stripped of their natural predators and often growing to overabundance (Adams & Lindsay 2010).

In short, of the inter-related changes brought on by human population growth, urban sprawl, habitat modification, fragmentation, the creation of "enhanced ecosystems", and changing public attitudes and uses of wildlife, human-wildlife conflict has increased in urban areas (Manfredo 2008). The increase in human-wildlife conflict is world-wide both in frequency and in severity, given that humans and wildlife are progressively forced to compete for space and resources (Madden 2004). The shared need of human and wildlife for space, resource use, and habitat inevitably leads to human-wildlife conflict, since it is impossible for all members of a geographic community to have all of their needs met in exactly the same geographical place (Lynn 1998). This is especially true, Lynn argues, of growing urban environments, resulting in shrinking wildland spaces necessary to sustain herds of herbivores and large carnivores and the essential associated biodiversity (Lynn 1998). It is generally accepted that the role of attempting to address human-wildlife conflict means understanding the role of humans as importantly as understanding the ecology of the species (Decker et al. 2001; Alexander & Quinn 2011).

Focusing specifically on WTD, their populations in North America continue to grow in urban environments resulting in an increasing occurrence of human-deer conflicts (Adams et al. 2006). WTD cause property damage by eating ornamental trees, shrubs, flower beds, vegetable gardens and fertilized lawns (Decker & Gavin 1987; Swihart et al. 1998; Conover 1997; VerCauteren et al. 2005). WTD also cause significant losses for agricultural producers. In the United States, white-tails are estimated to have caused $100 million in agricultural damage in 2001 (Conover 2002). In many metropolitan areas, where growing urban WTD populations exist, agricultural land, located both inside and just outside of urban areas, may experience substantial damage. WTD have substantially impacted the timber industry by feeding on growing trees and saplings, retarding tree growth, and altering the density and diversity of woody species (Conover et al. 1995; Waller and Alverson 1997).

WTD also pose a significant human safety concern, mainly given their involvement in an increasing and alarming number of motor vehicle accidents (Conover et al. 1995). Deer-vehicle collisions (DVCs) represent a human-wildlife conflict of serious concern, as they may result in significant risk to human safety, deer mortality, and vehicle damage (Finder et al. 1999). Additionally, WTD are a host for diseases transmittable to humans, a well-known WTD transmittable disease being Lyme disease. Lyme disease is a bacterial infection that people contract from the bite of an infected adult blacklegged deer tick (*Ixodes dammini*). Lyme disease is caused by the spirochete *Borrelia burgdorferi* (Pennsylvania Game Commission 2003). McCullough et al. (1997) suggest that deer moving back and forth between wildlands and urban areas bring deer ticks into frequent contact with humans and therefore the presence of deer in urban environments increases the risk of Lyme disease transmission (McCullough et al. 1997). Further, the increasing occurrence of Chronic Wasting Disease (CWD) in wild cervids in Canada may also alter urbanite tolerance of WTD residing in their neighborhoods. Now reported in two Canadian provinces, the potential spread of CWD (a transmissible spongiform encephalopathy affecting North American deer and elk) is an increasing concern (Miller 2012). While urbanites may tolerate or even attract WTD to their properties, the pendulum may quickly shift given the potential severity of human-deer conflict. It is evident that in the case of urban WTD, overlap and fluidity exist between "ecological" and "social" carrying capacities.

As urbanites become aware of the various pitfalls - such as property damage, DVCs, and Lyme disease transmission - that accompany living in close proximity to wildlife, they call on wildlife managers to reduce human-wildlife conflict (Decker et al. 2001). A study in the United States found that residents spend significant time and money attracting wildlife to their property; however, interestingly, these same residents are also likely to take wildlife management into their own hands when human-wildlife conflicts occur (Conover 1997). Conover argues that residents in urban areas who take action and matters into their own hands and attempt resident-management, lead to problems, especially when their action involves large mammals such as urban WTD (Conover 1997). The end result is often a community "at war" where "backyards are converted to battlegrounds" (Sterba 2012). The concept of urban species co-existence is quickly replaced by that of a municipal combat zones, depicted by humans against animals, while also equally so, of humans against each other. Residents experiencing human-wildlife conflict who feel the need to take matters into their own hands often leads to frustration, emotionally charged positions between residents, and further exacerbation of an already sensitive issue. Quickly, a majestic and valued species such as WTD becomes reduced to nothing more than descriptive terms such as "pest", "nuisance", or "problem" wildlife (Adams et al. 2006). How within this complex system can we successfully aspire to urban species co-existence when dealing with generalist wildlife populations that continue to grow and inevitably become associated with human-wildlife conflict?

1.2 Application

Urban WTD provide a case study of the ways in which contemporary wildlife managers are faced with increasingly complex human-wildlife problems. Many urban centers throughout North America are experiencing growing urban WTD populations (Brown et al. 2000; Doerr et al. 2001). The highly resilient and generalist nature of WTD has contributed to their ability to survive and thrive in human altered landscapes. A generalist species is a species which can tolerate a wide range of environmental conditions and wide niche breadths (MacDonald 2003). WTD find refuge in urban centers due to hunting restrictions, firearms discharge laws, and minimal predation (Conover et al. 1995; Messmer et al. 1997; Adams et al. 2006). Growing WTD populations along with hunting restrictions and conflicting social attitudes and perceptions with regard to wildlife, have resulted in higher deer densities throughout most of their North American range (DeNicola et al. 1997; Brown et al. 2000; Merrill et al. 2006; Kilpatrick et al. 2007; McDonald et al. 2007). Urban environments provide

WTD with adequate shelter, available water, and both natural and human-supplemented food sources (Adams et al. 2006). These factors, coupled with a high birth rate (DeNicola 2000; Adams et al. 2006), have resulted in increasing WTD populations in largely human populated areas.

The GWA, like many metropolitan North American centers over the last 50 years, has grown, converted undeveloped land to developed land, and extended city boundaries. The GWA has experienced a growth in both the human and urban WTD populations over the past two decades. WTD have been a part of the GWA landscape for over 100 years, although over the past two decades, the GWA has experienced substantial growth in the urban WTD population (Hagglund 2006). With the increase in the urban deer population size, an increase in the number of human-deer conflict cases has been reported (Manitoba Conservation and Water Stewardship (MCWS) unpublished data, Winnipeg District Occurrence Report).

The GWA picture accords with that of many other urban centers across North America. I argue that urban areas need to be designed in ways that incorporate natural spaces within the urban matrix and support the co-existence of species in order to slow the rate of biodiversity loss and potential species extinctions. WTD, however, are a generalist species that have been able to adapt to the heavily human manipulated spaces. In these expanding urban/suburban zones, dominated by high human population density, increasing WTD populations present numerous challenges for wildlife managers (Decker

& Gavin 1987; Stout et al. 1997). Successful co-existence requires a deeper understanding of species urban ecology and movement and the associated social dynamics that should be considered for management.

1.3 Objectives

This research aimed to gain a better understanding of GWA urban WTD movement and the related social and ecological considerations for management. The specific objectives of this research were as follows:

1. To explore WTD movement patterns within a developed landscape. To undertake this research, the study involved tracking of urban WTD movement within the GWA.
2. To improve our understanding of the similarities and differences of deer movement within GWA compared to deer movement within the larger un-fragmented blocks of habitat found within RMNP.
3. To investigate the influence of human social behaviour on urban deer movement patterns within the GWA.
4. To investigate the spatial and temporal occurrence of DVCs within the GWA and factors associated with high risk DVC roadways.

1.4 Thesis Structure

This dissertation is comprised of six chapters. Each of these chapters was written as a separate manuscript and as a result, some minor repetition exists between chapters. Chapter 1 describes the application of available theory to the context of this research, the thesis objectives, and thesis structure. Chapter 2 explores WTD movement within the GWA by considering the spatial and temporal aspects of urban deer movement, including urban deer home range size, seasonal movement patterns, and habitat selection. Further, this chapter explores WTD movement in RMNP to movement in the highly modified and developed urban GWA.

Chapter 3 offers a research note presenting critical considerations for wildlife managers embarking on an urban deer collaring program. This chapter contributes to existing literature by outlining important considerations and potential pitfalls of urban deer collaring research.

Chapter 4 identifies ways in which human behavior may influence urban deer movement patterns, and questions why specific residential properties seem to attract urban deer and therefore influence their movement patterns. This chapter also explores the wildlife value orientations and discrete emotions that are associated with the resident behavior of supplying artificial food sources to deer.

Chapter 5 presents a spatial and temporal analysis of the factors that are associated with DVCs to gain a better understanding of the variables that may be influencing urban deer movement onto and across roadways and thereby increasing the potential for harmful DVCs.

Chapter 6 is a concluding chapter that highlights the contributions this dissertation makes to new knowledge, specifically the contributions this thesis makes to methodological and empirical research. The chapter also presents a uniquely integrated research model, based on Global Positioning System (GPS) backed movement patterns, coupled with human dimension data, and an elaboration of co-existence principles.

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CHAPTER TWO

SPATIAL AND TEMPORAL LAND USE OF URBAN WHITE-TAILED DEER

2.1 Abstract

White-tailed deer (WTD) (*Odocoileus virginianus)* home range size, habitat use, and seasonal movement patterns were assessed within the Greater Winnipeg Area (GWA) in comparison to those residing in the rural area of Riding Mountain National Park (RMNP), Manitoba. Urban deer monthly home range sizes were significantly smaller (GWA average Minimum Convex Polygon [MCP] area = 2.21 km^2) than those of deer residing within RMNP (RMNP average MCP area = 6.65 km^2). Urban female deer home range size was substantially smaller than that of urban males. A majority of the GWA deer did not migrate between summer and winter core use areas, appearing to display a strong fidelity to an annual home range. Urban deer significantly used residential, developed spaces, with some of their shortest and slowest movements occurring in the heart of city neighborhoods, likely in association with the supply of artificial food resources. Given the relatively small home range size and strong fidelity to an annual home range displayed by urban deer, temperature and precipitation did not have a significant impact on urban deer movement. Management of urban deer habitats may be more important than once thought, and efforts to mitigate human-deer conflicts and the associated human-human conflicts within the GWA should be tailored specifically to these localized areas.

2.2 Introduction

Understanding white-tailed deer (WTD) (*Odocoileus virginianus*) spatial and temporal land use in urban environments is an essential component in the creation of effective urban deer management programs. Over the past several decades, many urban centers in North America have experienced a growth in WTD populations (Conover 1995; Brown et al. 2000; Fulton et al. 2004). As a result, increasingly, urban land use planning, within the complex mosaic of metropolitan space, needs to consider urban deer ecology and behavior. Urban environments are uniquely comprised of natural- and human-supplemented food sources, fragmented landscapes, remnant habitat patches, and a multifaceted network of roadways (Adams & Lindsey 2010), where both the benefits and liabilities of an urban deer population are realized. Within these spaces, both natural and human-induced factors influence WTD survival and movement. Understanding WTD movement patterns and habitat use is important for managers (Grund et al. 2002) and land planners attempting to reduce human-deer conflicts (Etter et al. 2002).

WTD seasonal movement patterns, migrations, and home range sizes vary considerably over their geographic range and landscape location. This variation is often based on deer response to changes in the availability and quality of resources (Marchinton & Hirth 1984; Brickman et al. 2005). Seasonal migrations of WTD between their summer and winter ranges typically occur in northern latitudes (Grovenburg 2009); however, differences in movement patterns may be observed between deer residing in rural versus urban landscapes (Etter et al. 2002; Bender et al. 2004). Typically, migration by WTD from a summer to winter range is influenced by changing temperatures, snow depth, photoperiod variations, and changes in the quality and availability of vegetation (Rongstad & Tester 1969; Verme 1973; Drolet 1976). Urban environments, however, provide unique foraging opportunities (Kilpatrick & Spohr 2000) including exotic plantings and artificial food sources that may offer deer atypical resources during winter months. Given the availability of these naturally uncommon resources, urban deer movement patterns and home range sizes may differ from those of deer residing in rural areas. Considering these factors, empirical information on deer home range size, habitat use, and seasonal movement patterns, specifically within urban environments, is an important consideration for management.

2.2.1 Urban Ecosystems

Complicating matters, urban ecosystem function is highly modified compared to WTDs natural ecosystem counterparts (Hilty et al. 2006). City environments often have their own microclimates, deriving energy from sources other than the sun, with variations in temperature, relative humidity, precipitation, and wind (Hilty et al. 2006). These urban landscapes often have overloaded biochemical cycles inundated with pesticides, fertilizers, and the burning of fossil fuels (Hilty et al. 2006). Urban development affects water runoff, infiltration, and purification processes. Further, the overall loss of larger intact contiguous blocks of undeveloped habitat impacts natural processes such as maintaining air quality, soil production, nutrient cycling, moderating climate, fresh water production, mitigating pollution, the degradation of wastes, and the control of disease and waste (Hilty et al. 2006).

However, despite their modified function, urban environments do offer high quality habitats for WTD, including adequate shelter, available water, and both natural and human-supplemented food sources (Adams et al. 2006; Adams & Lindsey 2010). Urban environments provide a distinct mosaic of stream corridors, forest fragments in parks and residential neighborhoods, patchy green spaces, and open recreational areas which, combined with hunting restrictions, firearm discharge laws, and minimal predation (Conover et al. 1995; Messmer et al. 1997; Adams et al. 2006; Adams & Lindsey 2010), provide ideal conditions for WTD. These factors, coupled with high birth rates and the highly resilient and adjustable nature of WTD (DeNicola et al. 2000; Adams et al. 2006), have resulted in growing WTD populations in many urban centers throughout North America (Brown et al. 2000; Doerr et al. 2001).

These growing urban WTD densities cause a myriad of ecological and social concerns. WTD cause residential and public property damage by eating natural and managed plantings (Decker & Gavin 1987; Conover 1997; Swihart et al. 1998; VerCauteren et al. 2005), and pose a significant human safety concern as they are host to a number of transmittable diseases, most notably Lyme disease (McCollough et al. 1997). Urban WTD are also involved in an increasing and alarming number of motor vehicle collisions (Conover et al. 1995). Large congregations of urban WTD may reside within small remnant habitat patches nestled within residential spaces, resulting in the localized reduction of plant species richness and structure, and thereby causing adverse effects on a variety of other local wildlife species (Jones & Witham 1990). These larger congregations of deer do not remain within these small remnant habitat patches but rather venture out of protective cover in search of additional resources. In light of this, multiple human-wildlife and inevitably, human-human conflicts, often accompany high deer densities in residential communities.

2.2.2 Management of Urban Deer

Management of WTD in urban landscapes has become a common concern in many urban areas (Conover et al. 1995; DeNicola et al. 2000). A variety of non-lethal and lethal strategies may be used to manage urban deer populations and to reduce human-deer conflict in metropolitan areas. Each management option is associated with various ecological, biological, or social benefits and liabilities. Some non-lethal methods of management include: public education (Lauber et al. 2007); habitat modification (Nielsen et al. 2003); prohibition of feeding deer (Doenier et al. 1997; DeNicola et al. 2000);

chemical repellents (DeNicola et al. 2000); scare tactics (VerCauteren et al. 2005); barrier fencing (Caslick & Decker 1979; DeNicola et al. 2000); road safety signage and vehicle speed control (DeNicola et al. 2000); deer vehicle whistles (DeNicola et al. 2000); trap and relocation (McCullough et al. 1997); immuno-contraceptives (Hernandez et al. 2006; Lauber et al. 2007); surgical sterilization (Merrill et al. 2006); and maintaining the status quo. These non-lethal methods of management may be the socially preferred options in some communities; however, they are often only moderately effective in reducing free-ranging deer populations and their associated conflicts; are expensive; in some cases, can be ethically questionable; and may have significant impacts on the social dynamics of the herd.

In comparison, site specific population reduction is a potential management option; however, studies have that shown many urbanites oppose lethal methods of management (Deblinger et al. 1995; McCullough et al. 1997; McCance 2009). Some potential lethal methods of management include: selective culls (DeNicola et al. 1997); trap and euthanize (DeNicola & Swihart 1997; DeNicola et al. 2000); sharpshooting (DeNicola et al. 1997), controlled hunts (Deblinder et al. 1995; Kilpatrick & Walter 1999; McDonald et al. 2007); and regulated bow and arrow hunts (Porter et al. 2004; Kilpatrick et al. 2007; McDonald et al. 2007). As is the case with the non-lethal methods, each lethal option has advantages and disadvantages. These methods, while generally effective at reducing the overall population, are costly, often require annual repetition, are in many communities socially unacceptable, and often only provide temporary relief of the conflict (Nielsen et al. 2003). In many cases, effective management is often site-specific and likely to include a combination of management options. In order to develop acceptable and effective management strategies, knowledge of deer seasonal movement patterns and their distribution in urban areas is necessary (Bender et al. 2004).

2.2.3 Urban Deer Movement Studies

Several studies have investigated deer movement in a wide variety of landscapes. Deer movement has been investigated in forests and wildlife refuges (Kernohan et al. 1996; Van Beest et al. 2013), agricultural (Brinkman et al. 2005; Grovenburg et al. 2009), and exurban areas (Kilpatrick & Spohr 2000; Storm et al. 2006; Rhoads et al. 2009). However, WTD movement within urban landscapes requires further investigation. Few studies, specifically using Global Positioning Systems (GPS) - backed data, have examined WTD movements in urban landscapes. Grund et al. 2002 studied seasonal movements and habitat use of female WTD in an urban park, and similarly Ekstein & Hygnstrom (1997) assessed WTD movement in an urban forest, while Jones & Witham (1990) investigated the survival and movement patterns of post-translocated urban WTD. Each of these studies used radio-collars. Further to these studies, Bender et al. 2004 assessed the annual and seasonal movement of black-tailed deer in Vancouver, British

Columbia, using relocated (1-2 times/week) radio-collared animals; and Piccolo et al. (2002) used radio collars on WTD in urban habitats around Chicago, Illinois. An opportunity exists to build on these research findings, so as to enhance the existing knowledge base with respect to the spatial and temporal movement patterns and habitat use of urban GPS collared WTD.

2.3 Objectives

Many urban centers throughout North America are experiencing growing urban WTD populations. Several of these urban areas have developed management strategies to address this issue; however, the basic movement patterns, corridor use, and habitat selection of urban WTD populations are often poorly understood (Grund et al. 2002). Currently, little is known about WTD daily and seasonal movement patterns in the urban areas of Canada.

The objective of this research was to examine the temporal and spatial land use of WTD in urban spaces. This research explored: 1) sex-specific seasonal home range sizes; 2) habitat use of WTD; and 3) seasonal movement patterns of WTD residing within a Canadian urban center, Winnipeg, Manitoba, Canada. For comparative analysis, WTD were also GPS collared in RMNP, a 2,969 km^2 federally protected area located 306 km northwest of Winnipeg. This research also investigated 4) the similarities and differences of the spatial and temporal movement patterns of urban versus rural WTD.

My premise was that, given the unique availability of resources, the reduced energy expenditure of travel, and the increased thermal protection found in metropolitan areas, urban WTD have smaller home range sizes than their rural counterparts.

2.4 Study Area

2.4.1 Greater Winnipeg Area

Winnipeg is the largest and capital city in the province of Manitoba Winnipeg (49°53'58'N, 97°08'21'W) is the 7th largest municipality in Canada, covering 464.01 km^2, with a human population of 730, 018 people (Canada 2011 Census). The GWA (elevation 238 meters) is located where historically a tall grass prairie ecosystem thrived (Scott 2007). The Greater Winnipeg Area (GWA) has a humid continental climate (Köppen Climate Classification) with an average of 318 sunny days/year and is characterized by four distinct seasons. Summers are typically humid and hot with temperatures rising to 35 degrees Celsius. There is a wide variation between summer and winter temperatures, as the typical winter in Winnipeg is long and cold with temperatures reaching minus 35 degrees Celsius. Snow conditions often cover the landscape for up to six months of the year (Environment Canada http://climate.weather.gc.ca).

WTD are non-native species and are relative newcomers to Manitoba with their arrival occurring sometime in the late 1800s (Goulden 1981). WTD expanded northward, extending their range from Minnesota into Manitoba, following the pattern of human settlement and taking advantage of edge habitat created by human land use practices such as pioneer agriculture and logging (Goulden 1981). Prior to human settlement, mule deer (now virtually non-existent) were the only deer found in any significant numbers in Manitoba. The earliest accounts of WTD in Manitoba occurred in 1881; however, it was not until 1900 that WTD were regularly seen by settlers (Goulden 1981).

WTD within the GWA take advantage of agricultural crops as a food source while also feeding on native plant species such as aspen (*Populus tremuloides*), clover (*Trifolium spp., Melilotus sp*.), oak (*Quercus macrocarpa*), Saskatoon (*Amelanchier anlnifolia*), snowberry (*Symphoricarpos occidentalis*), among others (Howe et al. 1974). The GWA deer herd also takes advantage of an adequate supply of supplemental food sources (Bulloch 1987).

Until the middle of the 1970s, GWA urban WTD numbers were less than 200 animals. Bylaws restricting the use of firearms within city limits (passed in the early 1980s) has likely contributed to the growth of the urban WTD population. An aerial survey conducted by Manitoba Conservation and Water Stewardship (MCWS) in 2006 identified 1788 WTD within the City of Winnipeg and its near surround area (Hagglund 2006). Deer density over the entirety of the GWA is only 2.2 deer/km^2; however, MCWS conducted a spatial analysis of landscapes in neighborhoods supporting WTD and determined the deer density within these GWA neighborhoods to be 55 deer/km², based on the 2006 aerial survey results (MCWS, unpublished data).

2.4.2 Riding Mountain National Park

RMNP, (approximately 50°51’50’N, 100°02’10’W) is a primarily forested protected area located in the southwestern portion of Manitoba (Smith et al. 1998). The mean annual temperature is 1.2 degrees Celsius with an average growing season of 173 days. The mean annual precipitation is approximately 500mm, of which roughly one quarter falls as snow (Smith et al. 1998). RMNP is located in the transitional zone between the prairie and the northern Boreal Plains eco-regions (Rowe 1972). The landscape surrounding RMNP is managed for agriculture, primarily annual cereal and oilseed crops, as well as perennial forage crops and pasture for beef cattle (Brook 2007). The eastern boundary of the park is characterized by the Manitoba Escarpment at 475m which gradually declines in elevation toward the western limit of the Park. The Park is located at the overlap of three land ecosystems; the Grasslands, and two sub-components of the Great Boreal Forest Biome, the Aspen-Oak and Mixedwood ecosystems (Ecological Stratification Working Group 1995). There are multiple small rivers and creeks draining in various directions from the region. The composition of vegetation consists of trembling aspen, balsam poplar, and jack pine stands, with occasional mixes of white spruce (Rowe 1972). Wet and poorly drained areas also contain black spruce, sometimes in combination with white spruce and trembling aspen on moist sites (Smith et al. 1998). Heavy moss ground cover can be found under coniferous stands on the north facing slopes while hazel shrub is common under mixed forest stands on the south and west facing slopes (Smith et al. 1998).

As a result of the diverse assemblage of plant species found within the Park many mammal species are found in the area including beaver (*Castor canadensis*), black bear (*Ursus americana*), coyote (*Canis latrans*), elk (*Cervus elaphus*), ermine (*Mustela erminea*), fisher (*Mustela pennanti*), grey wolf (*Canis lupus*), hare (*Lepus americanus*), least chipmunk (*Eutamias minimus*), lynx (*Lynx canadienses*), mink (*Martes vison*), moose (*Alces alces*), red fox (*Vulpes vulpes*), red squirrel (*Tamisciurus hudsonicus*), snowshoe otter (*Lutra canadensis*), southern red-backed vole (*Clethrionomys gapperi*), and WTD (*Odocoileus virginianus*) (CPAWS 2004).

Human harvest of wildlife within the park is restricted. Winter ungulate classified count surveys conducted in 2013 indicate approximately 2,100 WTD, 1,600 elk, and 2,700 moose within the Park (Data source: Parks Canada, RMNP). As noted, RMNP represents a multi predator-prey ecosystem. Systematic annual winter wolf surveys indicate a stable wolf population with a 2011-2012 population estimate of 113 individuals

(Data source: Parks Canada, RMNP). A population estimate for black bears in 2007 indicated approximately 900 black bears within RMNP (Parks Canada 2007).

2.5 Methods

2.5.1 Global Positioning Systems Data

WTD were captured and collared during winter months (December – March) within the GWA between 2010 and 2012. Deer were collared with Lotek Wild Cell M GSM collars (equipped with Lotek timed blast off units) using a modified robust version of Clover Box Traps (Clover 1956). Deer were captured on private residential properties and public lands located in the heart of urban space within the GWA. Clover box traps were set up and baited using sweet feed (an intended horse feed primarily made up of barley, oats, and corn covered with molasses) 48 hours prior to capture to acclimatize the deer to move in and out of the un-set trap. Urban Clover Box Traps were set at dusk and checked each evening at 9 pm, between 11 pm-12 am, and again at 6 am. Given the relatively high degree of human activity and disturbance inherent in the urban environment within which these trapping activities occurred, the traps were not set during daylight hours, so as to reduce, as much as possible, additional stress on captured deer. Given the nature of the research, the time required to work with each animal, and risks associated with each methodological approach, deer captured in Clover Box Traps were physically restrained, versus chemically immobilized, blindfolded, ear tagged, collared, and released. Latitude and longitude locational fixes were programmed to be taken every two hours. Once the animal was collared, data were sent to the researcher by cellular phone text message every ten hours, providing near "real-time" fix data. Further to the GPS locational data, the researcher located deer at a minimum of every 3 months, although often more frequently, using a hand-held receiver and yagi antennae. Deer locations were derived by using 3-5 bearings and used to validate the accuracy of the GPS locational data, with the GSM collar, accuracy is within 1 meter.

All GPS locational data were screened for large positional outliers. The data were visually investigated and the low confidence outliers, any GPS location points with a Dilution of Precision (DOP) >25 were removed.

WTD were also captured during winter months (December-March) within RMNP and collared with either ATS or Lotek GPS store on board pods, Lotek GPS 3300 store on board collars, or ATS G2110E iridium collars. Deer were collared either by ground using a modified robust version of Clover Box Traps (Clover 1956) baited with sweet feed, or by air, using aerial net-gunning techniques (Kock et al. 1987). Deer collared by ground or by aerial net gunning were all physically restrained, blindfolded, ear tagged, collared, and in the case of RMNP, blood was taken for Bovine Tuberculosis (TB) testing purposes prior to the animal's release. GPS collared WTD were initially captured in the western portion of RMNP, an area characterized by largely un-fragmented blocks of habitat with little to no human development or activity.

Similar to the GWA data, all RMNP GPS locational data were screened for large positional outliers and data investigated with low confidence outliers removed, any GPS location points with a DOP> 25 were removed. Given a variety of collar types were used within RMNP, the accuracy of location varied slightly based on collar type; however, accuracy is within 1-3 meters.

All animal capture and handling associated with this research was conducted in accordance with the capture and handling guidelines of the Canadian Council on Animal Care (2003), University of Manitoba Utilization Protocol number F09-034 Appendix A, a Parks Canada Agency Research and Collections Permit #2012-6993, and a MCWS Wildlife Scientific Permit #WB11818.

2.5.2 Sex-Specific Seasonal Home Ranges

All 'cleaned' GPS data were mapped using ArcGIS 9.3. Data fields were created to categorize the data by animal ID, sex, month, and season. Overall monthly and seasonal home range sizes, using 100% Minimum Convex Polygons (MCPs), were determined for each animal using Hawth's tools (Beyer 2004) in ArcGIS 9.3. For the purposes of this research, seasons were defined around life-cycle stages (i.e. rutting, parturition) being:

- Spring: April, May, June
- Summer: July, August, September
- Fall: October, November, December
- Winter: January, February, March (Brier & McCullough 1990).

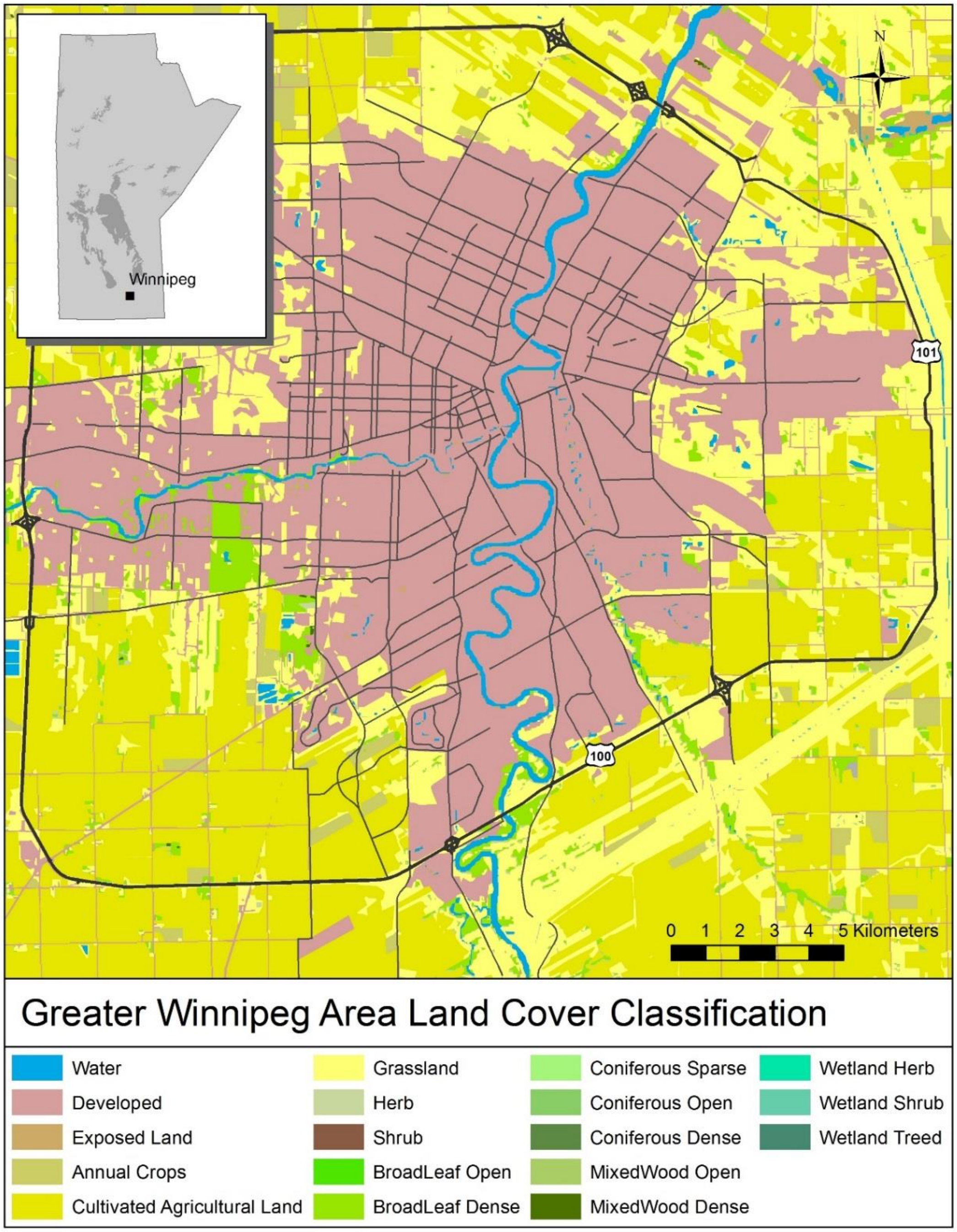
This analysis used the MCP technique, given that it is relatively robust with low sample sizes (Harris et al. 1990). Each MCP was carefully examined and any irregular outliers were investigated for each animal (Burt 1943). Welch's two-sample t-tests ($P<0.05$) assuming unequal variances (Moore 2000), were used to compare home range sizes between sexes and between GWA and RMNP collared deer.

To identify the areas used most intensively by each deer, adaptive kernels were also calculated for each animal at both the 90% occupancy and the 70% occupancy for annual home range. Using the Home Range Extension Function in ArcGIS 9.3 (Rodgers et al. 2007), high density core use areas were determined. A smoothing factor (h), which defines the spread of probability kernel generated for each observation point, of 0.4, was used (Hazell & Taylor 2008). The adaptive kernel, in comparison to the fixed kernel method, was selected for use in this research given this method varies the smoothing parameter so that areas with a low concentration of points have higher (h) values than areas with a high concentration of points, and are therefore, smoothed more (Worton 1989).

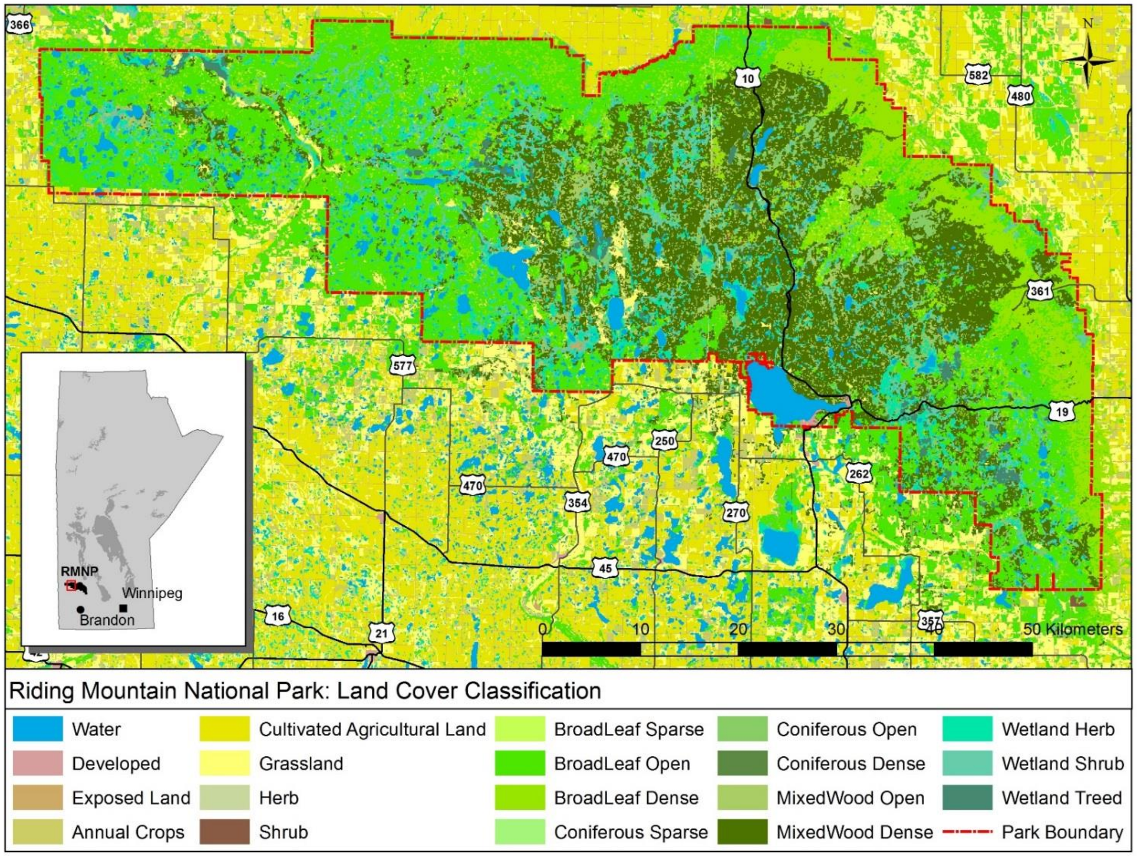
In order to assess whether deer migrated between summer and winter core use areas, the summer and winter 90% Adaptive Kernels (Brickman et al. 2005) for each collared deer, located in both GWA and RMNP, were analyzed to assess whether there was any degree of overlap between these two core use areas. For the purposes of this research, migration was defined, similar to Brickman et al. (2005), as the seasonal movement between non-over-lapping winter and summer core use areas. If any overlap between the seasonal core use areas was detected, migration was assumed not to have occurred. In cases where the two core use areas did not overlap, the linear distance from the center of the summer kernel to the center of the winter kernel was measured to assess the distance of the migration between a summer and winter core use areas. Results of this analysis were summarized.

2.5.3 Habitat Use

Animal locational data were spatially joined to the Canadian Land Cover Classification (LCC) layer. The LCC is a national land cover spatial database developed by the Canadian Federal government with data integrated from the major federal departments involved in land management in Canada, such as Agriculture and Agri-Foods Canada (AAFC), Canadian Forestry Service (CFS), and the Canadian Center for Remote Sensing (CCRS). The data resolution of the LCC is based on Landsat imagery and depending on the cell the imagery covers, is generally 1 meter. The data used for the LCC is classified and confirmed using parallel datasets and ground trothing to improve accuracy. Map 2.1 and Map 2.2 illustrate the LCC for the GWA and RMNP respectively. Using the LCC, the GPS locational fixes occurring in each LCC type was determined for both GWA and RMNP collared deer. The total number of locational fixes recorded in each land cover type was summarized. The sum of the area (square km) was calculated in relation to the LCC for the overall seasonal MCP and the seasonal 90% and 70% Adaptive Kernels.



Map 2.1: The Greater Winnipeg Area Land Cover Classification



Map 2.2: Riding Mountain National Park Land Cover Classification

Within ArcGIS 9.3, paths were created using a script called 'Create attributed lines from points' (Buja 2009), connecting each successive location. The total length of each path was measured using Hawth's Tools and the time between locations was measured using the Visual Basic Script Fixgap (Davis 2007). Data were filtered to remove locational data that did not comply with the 2 hr fix gap (data that had missed acquiring one or more consecutive satellite fixes). Only the data that had a 2 hr fix gap was used for this portion of the analysis. Using the distance and time between fixes, movement rates were calculated for each location. The length (m) and rate of each movement (m/hr) were calculated based on the time/distance of each fix to the preceding fix. The length of all GWA and RMNP collared deer movement measured between each 2 hr fix were totalled in relation to the LCC and averaged. The same process was repeated with the rate of movement within each 2 hr fix (totalled and then averaged) to determine the rates of movement in various habitat types for both the GWA collared animals and the RMNP collared animals. Movement rates were compared with the habitat associated with each cover type. Note: while there exists an inherent bias in this analysis, given only the animal location at the time of the fix can be determined with any certainty, over the broader scale of the data set, the results do provide valuable insights into deer use and movement rates through various land cover types.

2.5.4 Seasonal Movement Patterns

The length and rate of movement were calculated for the GWA and RMNP by season and by month. Using the length (m) of movement from each collared animal measured between each 2 hr fix gap, all of the 2 hr fix gap lengths by season and month were averaged to provide the average length of movement by season and by month for the GWA and RMNP animals. Similarly, the average speed of movement (m/hr) was determined by season and by month. Results were summarized and t-tests were used to determine whether there was a statistically significant difference between the length and speed of the movement of collared GWA deer in comparison to the collared RMNP deer. Further, in an effort to assess factors that may influence seasonal movement patterns of urban deer, the daily temperature and precipitation values were acquired from Environment Canada's National Climate Data and Information Archive (2010-2013) for both the GWA and Dauphin, Manitoba (located just north of RMNP) (http://climate.weatheroffice.gc.ca/Welcome_e.html). The daily MCP dimensions of each collared GWA deer (area, perimeter, length of MCP diameter) were calculated. The average of all collared animals' length of their daily MCP diameter (the average of the GWA collared deer and separately the average of the RMNP collared deer) were plotted against the average daily temperature and/or average daily precipitation and Spearman Rank Correlation analysis of the data were conducted using "R" Version 3.0.1

(http://CRAN_R_project.org/) to assess whether the temperature and/or precipitation influenced urban deer movement.

2.6 Results

2.6.1 Global Positioning Systems Data

A total of 18 WTD (n = 11 females, n = 7 males) were captured and collared in the GWA from March 2010 until January 2013. Of the 18 deer trapped and collared in the GWA, 8 of them were captured and collared during March. Consistent with the research conducted by Kilpatrick and Spohr (2000), in our geographic location, we found early March, when snow was still on the ground but deer were food- stressed, to be the most effective time to capture.

Of the total 18 deer collared, 2 of the deer died within the first month of being collared. Of these 2 deaths, one was a doe, subsequently necropsied and determined to have died due to suffocation from nose bots (*Cephenemyia*) while the other was a doe that died after being involved in a deer-vehicle collision (DVC). Therefore, the GWA data used for this analysis is based on a total of 16 collared deer. Of the remaining 16 collared deer, 10 of the collars remained on the deer for the duration of the collar lifecycle until the time of collar blast off, an additional 4 of the deer died due to DVC (5 of 18 total, 28%), 1 of the bucks (approximate age 7.5 yrs) died of unknown causes (determined by necropsy), and 1 doe went off line 11 months after she was collared, with her fate remaining unknown. The successful fix rate of the GWA collars was approximately 90% with very little screening required overall. The ‘cleaned’ GWA collared deer data acquired represents 62,630 deer locations.

A total of 29 WTD (n = 20 females, n = 9 males) were captured during winter months (December-March) within RMNP and collared from January 2011 until March 2013 with either ATS or Lotek GPS store on board pods (n = 8), Lotek GPS 3300 store on board collars (n = 12), or ATS G2110E iridium collars (n = 9). A total of 8 deer were captured by ground, while the remaining 21 deer were captured using aerial net gunning techniques.

Of the 29 collared deer, only 20 collared deer were used for this analysis given 1 collar slipped off a buck shortly after collaring; 1 doe died by wolf predation within days of collaring; 2 collars were damaged; 1 doe was euthanized shortly after collaring as blood testing indicated suspicious for TB; and 4 collars went missing. Of those 20 collars used for this analysis, 6 mortalities were identified as either suspected wolf kills (n = 5) or causes remaining unknown (n = 1); 5 of the collared deer were removed from the landscape as a part of the local TB program; and 9 of the collars were dropped and recovered. Any GPS fix locations with a DOP of >25 were removed from the dataset. The ‘cleaned’ RMNP collared deer data acquired represents 62,170 deer locations.

2.6.2 Sex-Specific Seasonal Home Ranges

The overall MCP for collared GWA and collar RMNP deer are found in Figure 2.1 and Figure 2.2 respectively.

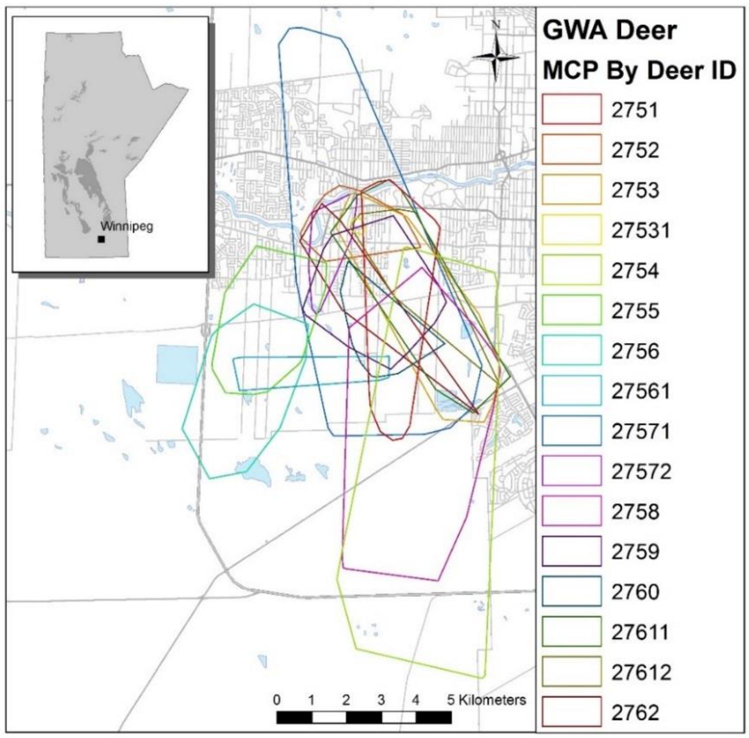


Figure 2.1: GWA Collared Deer MCP

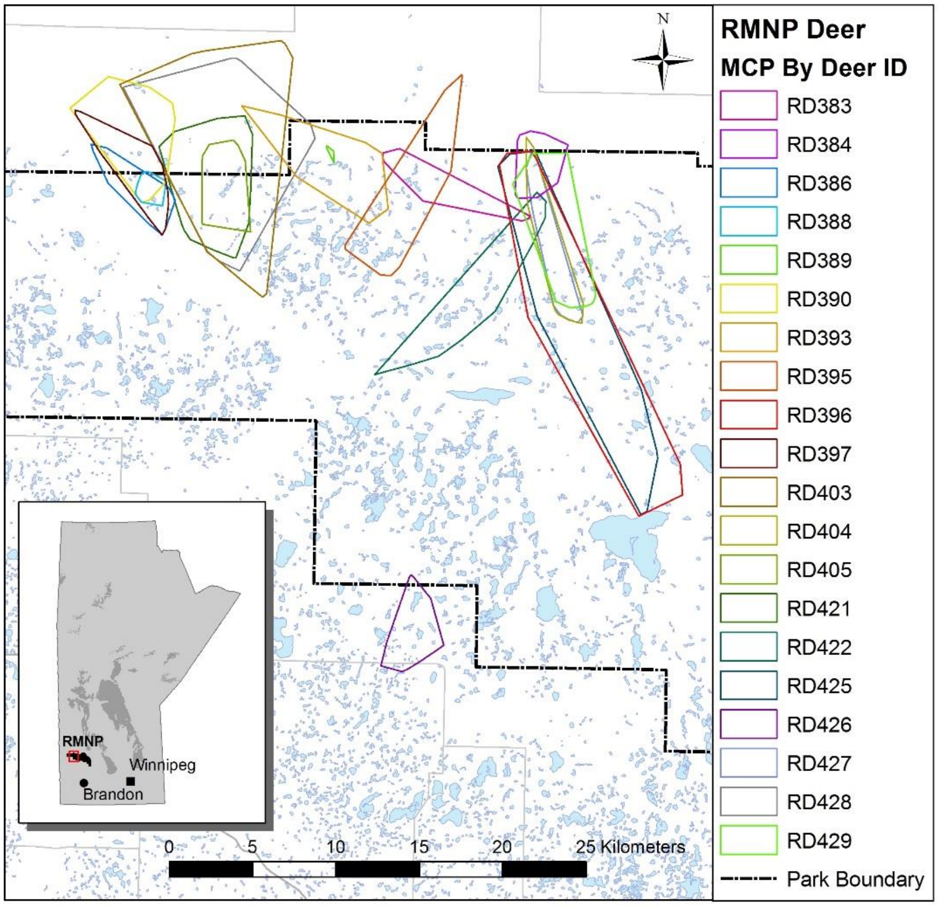


Figure 2.2: RMNP Collared Deer MCP

2.6.2.1 Monthly Home Range Size

The ‘cleaned’ GWA and RMNP collared deer data were used to determine the average area (square km) of their monthly MCP represented in Table 2.1.

Table 2.1: GWA & RMNP GPS Collared Deer Monthly MCPs (Average of Area km^2)

Month	GWA					RMNP				
	Females	SD	Males	SD	Males/Females Combined	Females	SD	Males	SD	Males/Females Combined
January	1.36	1.39	2.68	1.77	2.02	3.38	4.36	3.27	5.59	3.34
February	1.15	0.76	1.36	0.77	1.26	2.33	3.33	4.62	6.89	3.19
March	1.63	1.96	3.67	3.35	2.65	8.01	8.21	24.61	22.53	12.16
April	1.9	2.43	3.48	2.71	2.69	10.05	9.24	21.69	30.67	12.96
May	0.98	1.78	3.55	2.98	2.27	3.27	3.02	28.63	n/a	6.89
June	0.49	0.48	4.19	4.41	2.34	4.01	4.13	6.88	n/a	4.42
July	0.41	0.35	1.87	1.93	1.14	4.37	3.92	2.42	n/s	4.09
August	0.89	0.90	2.45	1.92	1.67	6.11	5.60	7.44	n/a	6.30
September	0.64	0.31	4.49	4.76	2.57	2.77	3.43	5.44	n/a	3.16
October	1.20	0.98	3.93	4.06	2.57	6.87	7.75	5.06	n/a	6.61
November	0.95	0.67	5.13	8.09	3.02	13.88	17.93	15.33	n/a	14.09
December	1.43	1.24	3.27	4.79	2.35	2.70	3.31	5.32	3.31	3.35
Average	1.09	1.10	3.34	3.46	2.21	5.66	6.19	10.43	13.79	6.65

T-tests confirmed a statistically significant difference between the home range sizes of GWA collared female deer (smaller) and male deer (P value = 0.00625< 0.05). T-tests also confirmed the difference of the average home range size of GWA collared deer (smaller) to be statistically significant compared to the average home range size of RMNP collared deer (P value = 0.028 <0.05). The t-tests failed to show a statistically significant difference, however, between male and female collared deer home range size in RMNP (P value = 0.187 > 0.05).

2.6.2.2 Seasonal Home Range Sizes

The cleaned GWA and RMNP collared deer data were used to determine the average area (square km) of the seasonal MCP and the 90% and 70% adaptive kernels, represented in Table 2.2.

Table 2.2: GWA & RMNP GPS Collared Deer Sex-Specific Seasonal MCPs, 90%, & 70% Adaptive Kernels (Average of Area km^2)

		Overall Seasonal MCP			Seasonal 90% Adaptive Kernel			Seasonal 70% Adaptive Kernel		
	Season	Females	Males	Males/Females Combined	Females	Males	Males/Females Combined	Females	Males	Males/Females Combined
GWA	**Fall**	1.23	4.00	2.76	1.59	2.45	2.06	0.62	0.81	0.72
	Spring	1.24	3.74	2.57	1.28	2.55	1.87	0.53	0.97	0.73
	Summer	0.69	2.77	1.84	0.63	2.58	1.63	0.27	0.91	0.59
	Winter	1.37	2.46	1.89	0.76	1.19	0.95	0.30	0.37	0.33
RMNP	**Fall**	16.81	13.46	16.22	6.07	5.99	6.06	2.29	2.40	2.31
	Spring	9.08	32.81	13.82	1.85	8.82	3.24	0.77	3.52	1.32
	Summer	5.97	9.08	6.49	1.29	4.12	1.76	0.60	1.61	0.77
	Winter	6.16	19.28	8.42	3.04	8.58	3.99	1.17	3.31	1.54

2.6.2.3 Seasonal Migration

Summer and winter 90% Adaptive Kernels were used to assess the degree of overlap, if any, between the summer and winter core use areas for each deer in the GWA and RMNP. Of the 16 collared GWA deer only four (25%) did not have overlapping core use areas during summer and winter. Of the four that showed a migration between summer and winter core use areas, three of the four were bucks, one of which, showed a migration between summer and winter ranges during both years the buck was collared.

Of the 20 GPS collared deer in RMNP, 17 of these deer were collared over the full duration of a full summer and winter season. Out of these 17 deer, only 4 (23.6%) did not have any overlap between their summer and winter 90% kernels. Of these 4, 3 were does and 1 was a buck.

Table 2.3 provides the linear distance between the two centers of the animal's 90% summer and winter kernels.

Table 2.3: GWA & RMNP GPS Collared Deer Migration between Summer and Winter 90% Adaptive Kernels (Average of Area km2)

Deer ID	Sex	Year	Region	Distance Between Centers (km)
2751	Female	2011	GWA	7.00
2754	Male	2011	GWA	7.00
2754	Male	2012	GWA	7.40
2755	Male	2011	GWA	2.30
2758	Male	2011	GWA	2.00
RD390	Female	2011	RMNP	5.10
RD396	Female	2012	RMNP	16.30
RD403	Male	2012	RMNP	7.60
RD425	Female	2012	RMNP	17.30

2.6.3 Habitat Use

2.6.3.1 GWA and RMNP Collared Movement in relation to LCC

Using the seasonal MCP, the 90% and 70% Adaptive Kernels for both the GWA and RMNP, the sum of the total area of each (square km) found within each LCC cover type were calculated and summarized in Table 2.4 and Table 2.5 respectively.

Table 2.4: Sum of Area of the GWA Collared Deer Seasonal MCP, 90%, and 70% Adaptive Kernels (Sum of Area km^2) in relation to LCC

LCC Category	GWA 90% Adaptive Kernel				GWA 70% Adaptive Kernel				GWA Overall Seasonal MCP			
	Fall	Spring	Summer	Winter	Fall	Spring	Summer	Winter	Fall	Spring	Summer	Winter
Annual Crops	2.03	2.71	1.25	0.42	0.68	0.96	0.48	0.12	1.93	1.94	2.15	1.40
BroadLeaf Dense	8.30	10.34	3.52	7.44	3.28	4.71	1.79	2.84	8.23	6.53	6.03	6.09
Cloud	0.07								0.07			
Cultivated Agricultural Land	14.89	13.11	22.14	3.37	4.02	4.02	7.15	1.20	40.14	39.67	50.40	18.78
Developed	11.63	7.96	2.80	9.41	3.97	2.88	0.96	2.46	28.00	13.82	12.05	12.91
Exposed Land	0.25	0.24	0.09	0.31	0.08	0.10	0.04	0.11	0.38	0.29	0.27	0.27
Grassland	18.24	12.48	5.46	10.32	7.33	5.71	2.32	4.18	14.07	10.88	10.66	10.04
Herb	0.92	0.68	0.39	0.43	0.51	0.36	0.17	0.19	0.73	0.63	0.56	0.56
MixedWood Dense	0.09	0.02	0.04	0.05	0.05	0.02	0.03	0.05	0.08	0.08	0.03	0.07
Water	1.11	1.01	0.20	0.56	0.34	0.32	0.01	0.14	1.13	0.78	0.78	0.94

Table 2.5: Sum of Area of the RMNP Collared Deer Seasonal MCP, 90%, and 70% Adaptive Kernels (Sum of Area km^2) in relation to LCC

LCC Category	RMNP 90% Adaptive Kernel				RMNP 70% Adaptive Kernel				RMNP Seasonal MCP			
	fall	spring	summer	winter	fall	spring	summer	winter	fall	spring	summer	winter
Annual Crops	1.12	0.79	0.21	2.69	0.39	0.17	0.00	1.32	4.35	4.29	4.11	6.22
BroadLeaf Dense	10.15	5.31	2.95	12.92	3.45	2.39	1.34	4.75	42.71	42.63	42.95	36.23
BroadLeaf Open	43.71	31.47	16.21	55.77	17.80	13.93	7.34	22.87	356.37	346.13	349.41	316.98
BroadLeaf Sparse	1.75	1.24	0.55	3.10	0.60	0.58	0.23	1.01	10.39	10.37	10.17	9.50
Coniferous Dense	0.00	0.10	0.03	0.01	0.00	0.05	0.02	0.00	0.30	0.30	0.30	0.30
Coniferous Open	0.78	0.24	0.15	0.32	0.39	0.06	0.06	0.06	4.47	4.97	4.27	3.45
Cultivated Agricultural Land	7.54	6.97	0.81	16.46	2.07	1.54	0.17	5.36	38.62	42.92	41.19	84.46
Developed	0.42	0.46	0.10	0.79	0.15	0.20	0.04	0.23	2.61	2.39	2.40	3.86
Exposed Land	0.15	0.14	0.05	0.09	0.08	0.07	0.02	0.04	0.96	0.98	0.96	0.68
Grassland	4.72	3.26	1.12	4.85	1.95	1.13	0.45	1.69	31.20	27.64	27.13	27.29
Herb	1.80	1.13	0.41	2.05	0.77	0.31	0.09	1.07	7.12	6.66	6.28	8.04
MixedWood Dense	11.97	4.13	2.64	2.37	4.18	1.73	1.13	0.47	47.28	51.61	47.65	22.66
MixedWood Open	3.58	1.83	1.32	0.62	1.84	0.99	0.93	0.18	10.48	11.34	10.66	3.74
Shrub Tall	0.29	0.17	0.14	0.02	0.23	0.13	0.11	0.00	0.48	0.49	0.46	0.08
Water	0.90	0.63	0.37	0.70	0.38	0.18	0.10	0.35	27.17	28.49	28.13	21.96
Wetland Herb	6.26	3.19	1.88	5.29	2.39	1.14	0.66	2.32	58.53	59.56	58.51	46.57
Wetland Shrub	7.40	3.06	2.63	5.87	2.46	1.58	1.14	1.93	56.53	57.70	57.11	45.80
Wetland Treed	0.45	0.68	0.15	1.83	0.09	0.30	0.01	1.01	15.53	15.02	13.84	8.33

2.6.3.2 Length and Rate of Movement in Various Habitat Types

Using the cleaned data representing 2 hr fix-gap data (GWA n = 58,893 locational data points; RMNP n = 52,978 locational data points), the total sum of the length of movement between each 2 hr fix gap for the GWA GPS collared deer within each LCC cover type was averaged to provide the average length (m) of movement in each LCC category, represented in Table 2.6. The same methods were repeated for the speed of movement (m/hr) between each 2 hr fix gap, totalled and then averaged in relation to the LCC cover types, represented in Table 2.7.

Table 2.6: GWA GPS Collared WTD Length of Movement between each 2 hr fix in Relation to LCC

LCC Category	Average of length (m)
Agriculture	296.08
Cultural	172.68
Deciduous Forest	166.58
Forage Crops	264.95
Grassland	187.76
Open Deciduous Forest	241.55
Roads/Trails	254.97
Water	234.72

Table 2.7: GWA GPS Collared WTD Rate of Movement (m/hr) between each 2 hr fix in Relation to LCC

LCC Category	Average of speed (m/hr)
Agriculture	148.03
Cultural	86.34
Deciduous Forest	83.29
Forage Crops	132.48
Grassland	93.88
Open Deciduous Forest	120.77
Roads/Trails	127.49
Water	117.36

2.6.4 Seasonal Movement Patterns

2.6.4.1 Length and Rate of Movement by Season

The total length of each collared animal's movement between each 2 hr fix gap was totalled and the average length of movement (m) by season for both the GWA and RMNP deer were summarized in Figure 2.3. Similarly, the average speed of movement (m/hr) by season was calculated and summarized in Figure 2.4.

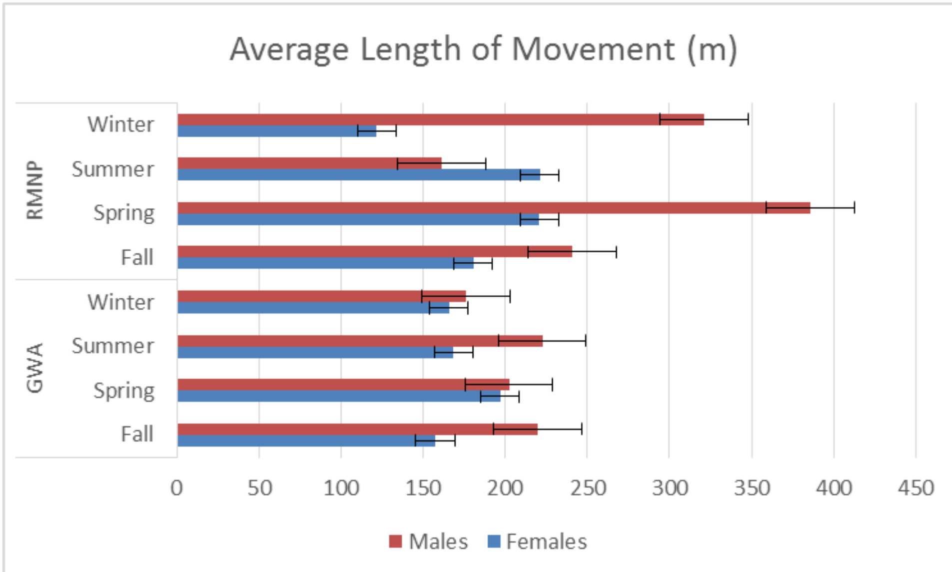


Figure 2.3: Average Length of Movement of GWA and RMNP Deer by Season

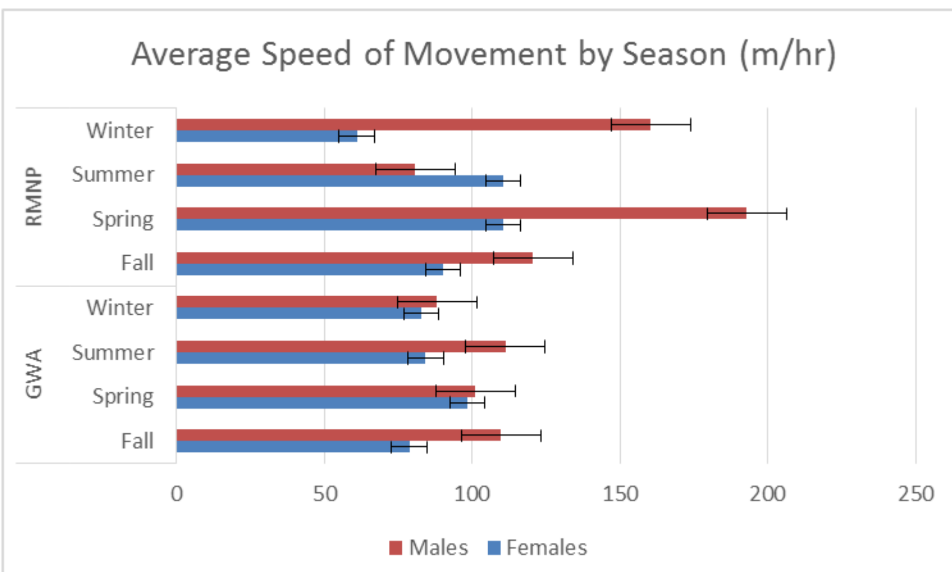


Figure 2.4: Average Speed of Movement of GWA and RMNP Deer by Season

2.6.4.2 Length and Rate of Movement by Month

The total length of each collared animal's movement between each 2 hr fix gap was totalled and the average length of movement (m) by month for both the GWA and RMNP deer were summarized in Figure 2.3. Similarly, the average speed of movement (m/hr) by month was calculated and summarized in Figure 2.4.

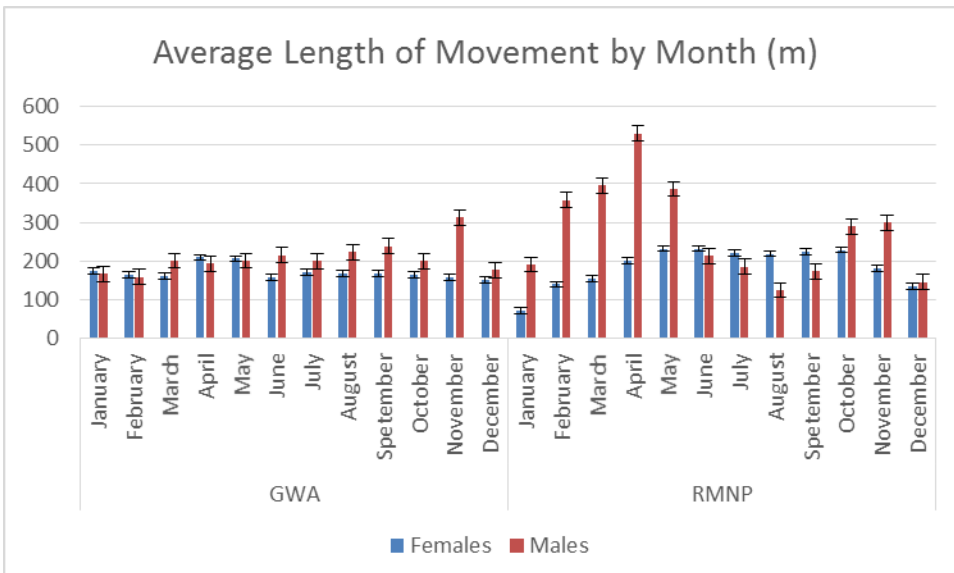


Figure 2.5: Average Length of Movement of GWA and RMNP Deer by Month

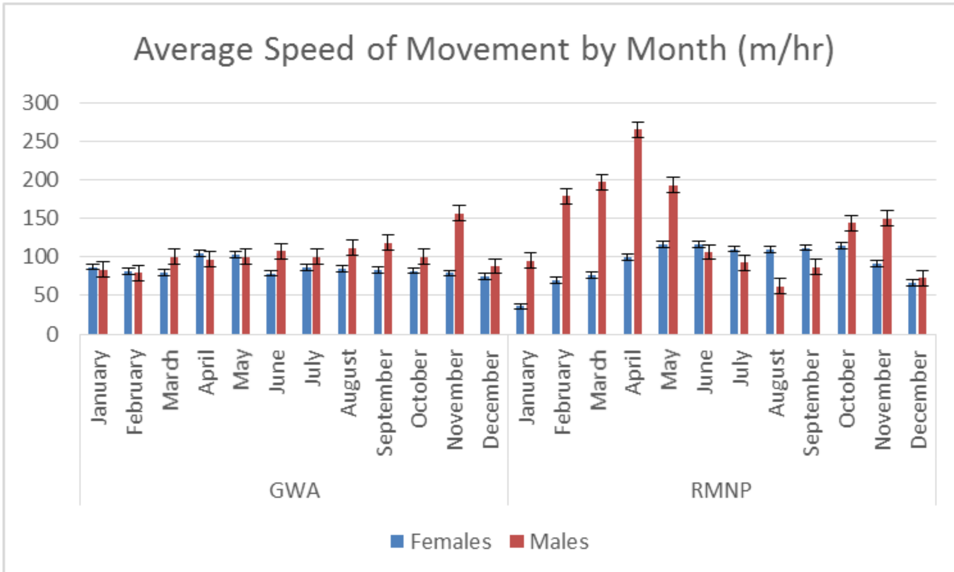
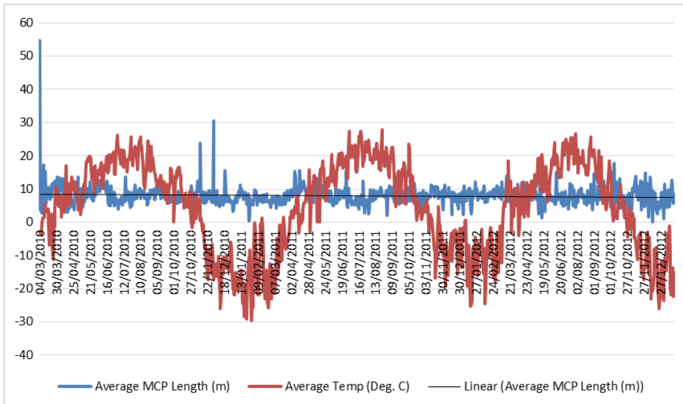


Figure 2.6: Average Speed of Movement of GWA and RMNP Deer by Month

T-tests failed to show a statistically significant difference between the average length and average speed of movement within the GWA compared to RMNP for both season (length P value = 0.584; rate P value = 0.583) and month (length P value = 0.469; rate P value = 0.468).

2.6.4.3 Temperature and Precipitation influence on Seasonal Movement

The average length of the daily MCP diameter of collared GWA deer (Figure 2.7) and collared RMNP deer (Figure 2.8) were plotted in relation to average daily temperature (degrees Celsius) and average daily precipitation (cm). Spearman rank correlation analysis was performed to determine whether temperature and/or precipitation influenced deer movement.



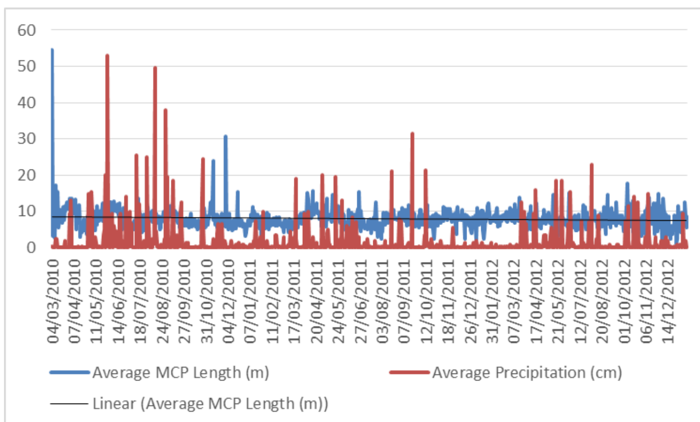


Figure 2.7: GWA Collar Deer Average Daily MCP Diameter (m) in relation to Local Temperature (degrees Celsius) and Precipitation (cm)

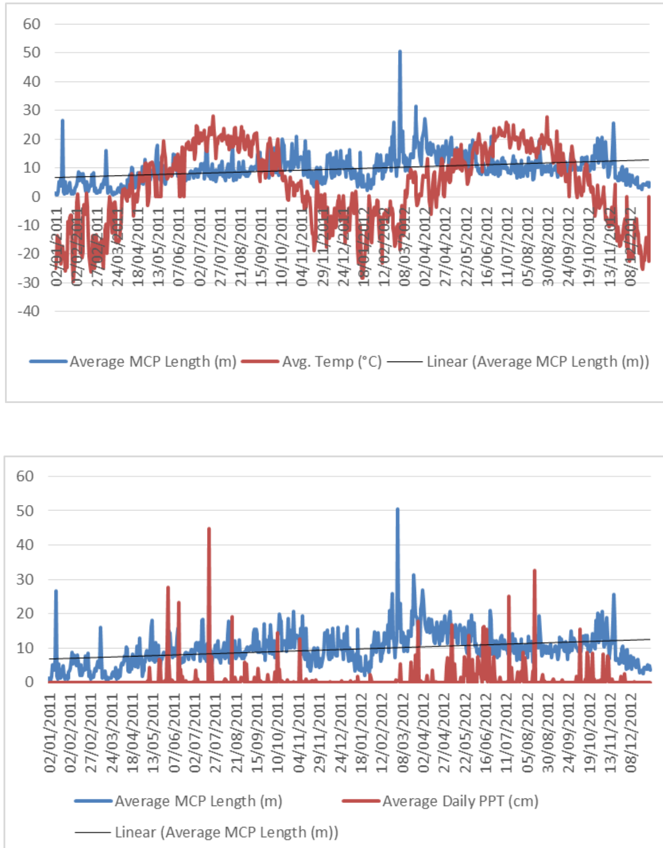


Figure 2.8: RMNP Collar Deer Average Daily MCP Diameter (meters) in relation to Local Temperature (degrees Celsius) and Precipitation (cm)

The spearman rank correlation analysis indicated no influence of temperature and/or precipitation on the GWA collared deer movement. Spearman correlation of +1 or −1 indicates one variable (in this case, daily movement in relation to temperature or precipitation) is a function of the other. The spearman rho (r_s) values for both temperature and precipitation effect on GWA collared deer movement were extremely small and close to zero, with P values greater than 0.05, indicating that neither were significant and that neither temperature nor precipitation explained changes in collared urban deer movement. The r_s values for the influence of temperature and precipitation on RMNP collared deer movement were both small; however, the P values for temperature and precipitation were less than 0.05 indicating a significance relationship (RMNP movement in relation to PPT P value = 0.000188; RMNP movement in relation to temperature P value = 2.2 e -16). Therefore, unlike the GWA collared deer, both precipitation and temperature influence RMNP collared deer movement.

2.7 Discussion

These results suggest deer have adapted to urban environments by decreasing their home range size and by using habitats unique to urban landscapes i.e. residential neighborhoods, similar to findings of Grund et al. (2002) who identified urban WTD home range size to be statistically smaller than those commonly reported for rural WTD. Consistent with their findings, this research shows overall substantially smaller home range sizes of collared deer residing in the GWA in comparison to collared deer residing in RMNP. In the case of this research, the combined average of total monthly MCP area in the GWA = 2.21 km^2 was significantly smaller when compared to the combined average of total monthly MCP area in RMNP = 6.65 km^2. Rhoads et al. (2010) note urban-suburban WTD annual home range sizes tend to be <50% smaller than those of WTD residing in rural-agricultural areas. Etter et al. (2002) and Grund et al. (2002) found urban WTD home ranges to be smaller in summer than winter. This data suggests only marginal differences between summer and winter home range sizes. Within the

GWA, males have larger home range sizes than females, with females exhibiting the largest home ranges in March and males exhibiting the largest home range size in November. Seasonally, females have the largest home range size in winter, with their home ranges expanding toward the end of March, likely as their metabolism increases, they progress furthering into pregnancy, and as such are searching for additional resources. Seasonally, males have the largest home range in fall, which is not surprising giving this coincides with the breeding season.

Results of this research also illustrated that urban deer demonstrate a high degree of fidelity to their home range. Only 25% of the urban deer migrated from a summer to winter home range. Of these migrants, 75% were males. RMNP collared deer that did migrate between summer and winter ranges displayed longer migrations between ranges than displayed by the collared GWA deer. Similar to the work of Grund et al. (2002), the urban home range sizes and seasonal shifts were smaller than noted in rural landscapes.

Several studies conducted in rural landscapes (Nelson & Mech 1981; Ozoga et al. 1982; Nixon et al. 1991) have noted that deer avoid high human activity areas, generally selecting secluded areas; however, these results, similar to Grund et al. (2002), identified GWA collared deer residing in the heart of residential space. Researcher observation indicates that GWA collared deer spend considerable time in close proximity to, and even direct contact with, their human neighbors. The findings reveal urban deer significantly use developed spaces and vacant grasslands found on crown land property strips located behind residential homes in these GWA neighborhoods. Some of the smallest lengths of movement and slowest rates of movement made by urban deer were within the cultural, developed spaces (Table 2.5 & Table 2.6). Conversely, the longest and fastest rates of movement made by collared GWA deer were observed on agricultural lands, which within the GWA, are located between developed spaces and tracks of in-tact broadleaf forest habitats. Deer traveling across these open landscapes have no protective cover available.

Based on both the empirical movement data and researcher observation, many of these collared urban deer spent a considerable amount of their time on specific residential properties, taking advantage of confirmed artificially supplied food sources (see Chapter 3). Researcher observations of dogs off leash chasing deer away from artificial food supplies did not deter these deer from returning to the artificial food site multiple times each day. Deer home ranges are small with little seasonal variation or migration within the city likely due to residents providing a year-round artificial food source.

GWA urban deer displayed little seasonal or monthly variation in the length or rate of their movement, likely due to deer taking advantage of these readily available high protein food sources, as well as many of the other benefits that urban environments provide such as the urban heat effect. Tall buildings and infrastructure within urban environments likely slow windchill effects and offer the advantage of increased heat from the thermal energy radiation from buildings. Further, urban deer energy demands are also reduced as deer take advantage of the easy travel routes offered by roadways, sidewalks, and trails with compacted snow rather than having to traverse through deep snow.

This study did not find that daily changes in temperature and precipitation had a strong influence on urban deer movement in the GWA, unlike the RMNP collared deer where temperature and precipitation did influence deer movement. Given the smaller home range size and the strong fidelity to an annual home range displayed by GWA collared deer, this is not surprising.

2.8 Management Implications

Deer spatial and temporal movement patterns and habitat use should be incorporated into urban deer management programs to maximize efficient use of municipal resources and to enhance program success. Results of this research indicate that a majority of urban deer do not make significant shifts in their home range sizes or migrate between summer and winter core use areas. This is likely a result of intentionally supplied artificial food sources that offer deer the advantage high protein food options throughout the year. Therefore, management of human-deer conflicts and human-human conflicts are likely localized in specific areas within the city. Given the costs associated with increasing DVCs and other deer conflicts, status quo management is no longer a feasible management option. In the GWA, bylaws prohibiting deer feeding might usefully be adopted and funding allocated to the enforcement of non-compliance. Further follow-up research of GPS backed urban deer movement patterns should be untaken as artificial food sources are diminished. Given the current fidelity of urban deer to a small seasonal range, results of this research suggest that management of these habitats may be more important than previously realized.

2.9 Conclusions

Today's wildlife managers are faced with the task of deer management within an urban matrix. WTD have adapted to exploiting suitable habitats and unique resources found within the heart of residential spaces. In these human populated environments, management options become limited. Deer home range sizes are smaller, potentially due to deer travelling shortened distances to find food and cover. These smaller urban deer home range sizes, with little seasonal variation in movement, are entwined within the fabric of residential neighborhoods, making many management options difficult to entertain and limited with respect to their anticipated success. Understanding urban deer movement and habitat use will assist managers and landscape designers in minimizing urban deer conflicts by designing management options tailored to urban deer ecology and behavior. Enhanced knowledge of the seasonal movements and habitat selection of WTD in urban areas will enable managing agencies and community leaders to make sound decisions regarding deer management strategies, land use, and resource protection.

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CHAPTER THREE

CRITICAL CONSIDERATIONS FOR AN URBAN DEER COLLARING PROGRAM

3.1 Abstract

Capture, handling, and collaring of wildlife within urban environments entails unique factors compared to similar programs conducted in more remote locations. Traditionally, wildlife management has occurred primarily in rural landscapes. As a result of this, wildlife managers have only recently become aware of the challenges distinct to urban spaces. As urban white-tailed deer (WTD) (*Odocoileus virginianus*) populations continue to grow in North America, the need to gain a better understanding of urban deer behavior and ecology becomes increasingly important for management. Global Positioning System (GPS) collars used to track wildlife movement are an effective tool offering the capacity to acquire valuable information on wildlife spatial and temporal land use patterns. Given this, urban deer capture and GPS collaring programs are likely to be adopted more frequently in the future. The following research note offers critical considerations for wildlife managers embarking on an urban deer collaring program, specifically in northern latitudes. The research note includes suggestions for selection of tracking collar, cage trap specifications, and other aspects that should be considered when capturing and physically immobilizing deer within metropolitan landscapes.

3.2 Introduction

Increasing human population growth and the tendency toward urban lifestyles have resulted in the extension of city boundaries and the outward development of residential and commercial spaces from city centers. These human-induced land use changes have modified the continental (and global) landscape, resulting, in some cases, in changes to wildlife species behavior and ecology (Adams & Lindsey 2010). In North America, white-tailed deer (*Odocoileus virginianus*) (WTD) populations have grown over the last several decades and they have adapted to life in urban environments (Kilpatrick & Spohr 2000; Etter et al. 2002; Bender et al. 2004). WTD have learned to exploit the variety of atypical resources available within developed urban spaces. In response to these growing urban deer populations, numerous metropolitan centers in North America are now faced with urban WTD management (Adams & Lindsey 2010). Deer populations within urban landscapes draw controversy given their association with human-wildlife conflict (Bender et al. 2004). Overabundant deer populations present human health and safety concerns as well as economic and ecological issues (Etter et al. 2002). As a result of the inter-related impacts associated with growing urban WTD populations, research investigating urban deer ecology and behavior becomes progressively more important. Researchers suspect that urban deer management will gradually become common practice (Grund et al. 2002). Understanding deer habitat use and movement patterns within urban spaces is necessary to maximize the success of management (Bender et al. 2004).

The use of Global Positioning System (GPS) telemetry collars in wildlife research has revolutionized the acquisition of animal-borne locational data, providing valuable information on animal behavior and ecology (Blackie 2010). GPS technology offers the researchers the ability to monitor fine-scale movement with a high degree of accuracy (Van Moorter et al. 2010). Urban deer collaring programs, however, pose unique challenges compared to collaring programs designed for remote locations. The following research note offers critical considerations for wildlife managers and researchers embarking on an urban WTD collaring program, specifically in northern latitudes, with respect to tracking collar considerations, cage trap specifications, and other factors when conducting deer capture within urban environments. These findings represent some lessons learned during a three year urban deer collaring program conducted in the Greater Winnipeg Area (GWA), Manitoba, Canada.

3.3 Tracking Collar Considerations

Essential to any wildlife collaring program is the selection of an effective collar that adequately complements the nature of the intended research. Appropriate collar selection within urban environments requires distinct considerations that may be less crucial to bear in mind when conducting research in a rural environment.

3.3.1 VHF technology

Very high frequency (VHF) collars offer an inexpensive, light-weight option for tracking wildlife. However, various constraints associated with VHF technology limit the accuracy and the number of locations that can be collected within a given time-frame (Kochanny et al. 2008). VHF radio-tracking technology remains a particularly labor-intensive and time-consuming technique (Samuel and Fuller 1996; Blackie 2010). The constraints associated with VHF collars are compounded within an urban environment. Despite their feasibility and attractive weight and size, relying solely on VHF collar technology is challenging in urban environments that are riddled with “noise” due to static and interference associated with electrical power lines, overhead airline traffic, and hindrance from buildings and homes, along with numerous additional competing radio-frequencies and other variables.

Above-and-beyond these interference issues, radio-tracking of free-ranging ungulates residing within the fabric of residential neighborhoods presents challenges. Researchers attempting to locate collared deer are confronted with issues of trespassing on numerous private residential properties and traversing barrier fencing, making the effective acquisition of a target animal’s location difficult. In an effort to obtain a consistent and robust dataset and to ensure that collared animals are not “lost” during a dispersal or migration event, deer must be located often when relying exclusively on VHF technology. Researchers need to ensure that their frequent presence while tracking collared deer does not influence deer movement, specifically within urban spaces comprised of primary and secondary roadways. Researchers need also to ensure that their presence does not “push” target and non-target deer onto and across busy roadways. While VHF technology is an essential complementary component of any tracking collar, relying solely on VHF technology within urban environments presents numerous challenges.

3.3.2 GPS Collar Specification Considerations

The use of GPS collars on free-ranging ungulates overcomes many of the limitations experienced with conventional VHF collars (Rodgers et al. 1996; Kochanny et al 2008). GPS collars offer numerous benefits, including the most precise locational data, frequent animal relocations, and reductions in temporal biases (daylight, weather) (Johnson et al. 2002). While GPS collars are equipped with greater technological capacities, they are generally heavier than their VHF counterparts. When selecting a GPS collar, researchers often consider the balance between battery power (collar life longevity based on fix schedule programming) and collar weight. In general, weight reduction indirectly affects the longevity of the GPS collar (Tomkiewicz 1996). Within an urban environment, GPS collar weight and overall collar volume are critically important. Unlike remote environments, urban areas are dominated by high human population density. Deer collared for research and management purposes often reside in spaces shared with humans. Their human neighbors often have a wide range of perspectives with respect to the deer residing within their neighborhoods, and may or may not agree with the use of tracking collars on deer (see Chapter 4). Depending on the community, urban residents may view urban deer as they would their domestic pets and as such, feel protective of their well-being (Manfredo et al. 2003; Manfredo 2008).

Based on best practices of animal ethics (Canadian Council for Animal Care Guidelines), when deer are exposed to the stress of capture and handling, researchers aim to ensure that the maximum amount of data possible is acquired from the undertaking. As a general “rule of thumb”, a tracking collar can weigh up to 3-5% of an animal’s body weight (Cochran 1980; Sirtrack: Wildlife Tracking Solutions, webpage accessed July 16, 2013). Researchers may be tempted to select a heavier collar in order to acquire data on the same research animal over multiple years. As an example, a 950 gram GPS tracking collar falls well within this weight category for WTD, and on average, if programmed to acquire a latitude and longitude locational fix every two hours, would last approximately two years, depending on a variety of factors. Based on the experiences of our urban deer collaring program, however, we would be cautious about using a GPS collar weighing 950 grams for future urban deer research. A heavy GPS collar can be associated with hair loss, chaffing, and rubbing of the skin around the animal’s neck, not to mention the collar’s potential appearance to some urban residents as cumbersome and overly invasive (Chapter 4). In light of this, despite a researcher’s desire to learn as much as possible from a collaring program and a researcher’s subsequent tendency to choose a collar with a larger battery and therefore, increased collar longevity, researchers in an urban environment should be cautious with respect to the weight of the collar they select.

A further consideration as to the overall collar weight is deer behavior, which in and of itself exacerbates collar hair wear. Deer foraging behavior results in the repeated motion of deer dropping their heads down to the ground to feed and then lifting their heads back up again. The continual up-and-down motion results in slight collar movement along the neck. Collaring mature does and avoiding the collaring of yearlings will assist researchers in acquiring a better collar fit at the time deer are collared. However, in our experiences, even a doe with a collar sized effectively and snug at the time of collaring is likely to experience some degree of collar movement along the neckline throughout the year, as her body condition fluctuates and her coat changes seasonally - with spring, in northern latitude of the GWA (approximately 49°53'58'N, 97°08'21'W), showing the most pronounced collar movement and associated effects. The repeated motion of the GPS collar moving, even slightly along the neckline, may result in damage to winter pelage, more substantial hair-wear, and in some cases, chaffing of the skin, a situation exacerbated by a heavy collar. Urbanites observing collared deer displaying these conditions may become alarmed, resulting in increased public concerns and increased pressure on both the research objectives and the researcher.

In combination with collar weight, collar volume is also a critically important factor to consider. Within an urban environment, selecting collars that are not bulky, that are contoured to the shape of the animal’s neck, and that are darkly colored, is advised. A well-designed collar, effectively contoured to the shape of the animal’s neck, with minimal collar volume, can reduce unnecessary attention being drawn to urban collared animals.

3.3.3 GPS Collar Drop-Offs

Within metropolitan spaces, re-trapping a collared target animal can be a difficult undertaking. Inside city spaces, aerial capture is often restricted; the use of cannon or rocket launched nets may draw undesirable attention; chemical immobilization of free-ranging ungulates in a matrix of busy roadways presents safety hazards; and the selective recapture of an already captured deer by drop-net and box trap can be difficult and time-consuming. Using an automatic drop-off mechanism associated with the tracking collar eliminates the need for the researcher to re-capture target animals, reducing stress on the animals (NPWRC: http://www.npwrc.usgs.gov/). While timed-drop-off units (should they work) do not require the researcher to recapture the collared animal, they do not offer the flexibility of remotely releasing the collar upon command. Given the unique dynamics inherent within an urban deer collaring program, researchers should consider the use of a collar and drop-off mechanism that offers two-way communication and support the collar release upon command.

3.4 Cage Trap Selection Specifications

Considerable time, energy, and expense are involved in capturing urban WTD (VerCauteren et al 1999; DelGiudice et al. 2005). The most critical aspects of handling WTD are ensuring safety, efficiency, and humane capture (VerCauteren et al. 1999). Cage traps have long been used as a safe and humane method of capture. Clover box traps have been an effective deer capture method associated with lower levels of induced stress in WTD in comparison with other available capture methods (DeNicola 1997). VerCauteren et al. (1999), using Clover box traps, captured over 1,000 WTD with less than 4% of captured deer suffering injury. Clover box traps offer a lighter weight and portable option (multiple traps can fit into the back of a truck bed) than some of the traditional box traps, such as the Stevenson box trap (VerCauteren et al. 1999). Deer are likely to enter into the Clover box trap with less hesitance given deer can see through the mesh sides. The mesh sides also provide the advantage of absorbing the shock of deer and handler movement within the trap, resulting in less injury. The disadvantage to the Clover box trap is that restrained deer are vulnerable to potential predation and to surrounding disturbances (VerCauteren et al. 1999).

The single-gate netted cage trap, which bears the Clover trap name, was first published by Melvin Clover in 1954 with a revision to trap specifications published in 1956 (Clover 1954, 1956). In 1975, additional revisions were offered in a publication by Dale McCullough, outlining modifications for trap collapse and suggested improved efficiencies to the overall trap design (McCullough 1975). More recent modifications to trap specifications were published by VerCauteren et al. 1999.

While building on the earlier work of VerCauteren et al. (1999), the Clover box trap specifications adopted for this research suggest using alternative materials and making slight alterations to their published trap design in order to facilitate the development of a robust version of the Clover trap better suited for northern WTD. I found that the heavier body weight and larger size of northern white-tails (large males weigh well over 90 kg/200 lbs), in combination with physical vs. chemical immobilization of deer, requires a heavier trap. Wildlife managers and researchers may find the heavier trap model to be useful given that urban white-tails will likely continue to improve their body condition in response to the annual supply of atypical food sources available in metropolitan spaces. Therefore, use of a heavier gauge cage trap for ground capture of WTD (both in northern and mid-continental latitudes) may prove beneficial.

What follows for the balance of this section are the trap specifications used for the present research and developed by Parks Canada biologists working at Riding Mountain National Park (RMNP). Table 3.1 represents a list of materials required for the Clover box trap construction and set up in the field. I then turn to “step-by-step” instructions for trap assembly, instructions presented in a “how-to” manual style.

Table 3.1: List of Materials for Clover Box Trap Construction

Number	Item	Length (inches)	Length (mm)	Number of pieces
1	Length pieces (1 inch square tubing)	72	1829	4
2	Width pieces (1 inch square tubing)	34	864	4
3	Upright pieces (1 inch square tubing)	48	1219	4
4	Drop-door guide upright (1 inch square tubing)	48	1219	2
5	Door pull-down bar (3/4 inch rod)	27	686	1
6	Door pull-down end rings	2.5	64	2
7	3/8 bolts and locking nuts	3	76	24
8	1.5-2" (38-51mm) mesh netting	48 x 34 (ends)	48 x 34 (ends)	2
9	1.5-2" (38-51mm)mesh netting	134 x 74 (sides & top)	134 x 74 (sides & top)	1
11	threaded I-bolts (tie-down leads)	1.5" eye with 3/8 x 1.5" bolt	38mm eye with 10 x 38mm bolt	4
12	threaded I-bolts (trip string leads)	0.75 eye with 1/4 x 1.5" bolt	19mm eye with 6 x 38mm bolt	6
13	Rat trap (trigger)	3 1/4 x 7	83 x 178	1
14	String	96	2438	2
15	Cotter pin	3	76	1
16	Paper clip	large	large	1
17	Corner angle supports (1 inch (25mm)square tubing, lighter tubing can be used)	24	24	2
18	Trigger string supports (1 inch (25mm) square tubing, lighter tubing can be used)	50	1270	2
19	Square Wire Locking Pin	3 x 3/8's	3 x 10mm	4
20	Outdoor Cable ties	8	8	4+
21	Rachet Straps	240	6096	2

Building on McCullough's (1975) modified Clover design, the trap corners are constructed to pivot, allowing handlers to collapse the trap for transport and, if desired, for handling. Initial steps of trap construction are to ensure all of the frame pieces are cut to length. Using a 3/8 bit (and a drill press, if available), drill holes 3/4" (19 mm) from both ends of the 48" (122 cm) pieces. Drill additional holes 1 1/2" (38 mm) from both ends of the 48" (122 cm) tubing, perpendicular to the first holes. Drill one hole 20" (508 mm) down from the top of 2 of the uprights (same direction as the very end holes). These last holes will be used for the support bars to be placed in the opposite corners of trap.

Continue to drill all holes required for trap assembly. On the two drop-door uprights, drill holes 1 ½" (38 mm) from both ends of the 48" (122 cm) frame pieces. Weld the 2 ½" (64 mm) rings to the ends of the pull-down bar.

On the tubing frame pieces that form the length of the frame, drill holes 5" (127 mm) from both ends of the top 66" (168 cm) pieces, to be used for the tie down strap 1 1/2" (13 mm) I-bolts. The rachet straps run through these I-bolts and are used to anchor the trap firmly to the ground. Along the top left 66" (168 cm) length tubing, drill two holes at 45" (114 cm) and 49" (125 cm) from the front, which will be used for the rat trap attachment. Further, using a 1/4" (6 mm) bit, drill two holes at 12" (305 mm) and 33" (838 mm) from the front of the top left 66" (168 cm) piece for the trigger assembly. Using the 3/8" (10 mm) bit, drill holes 3/4" (19 mm) from both ends of all lengths and 24" (610 mm) from the back end of both bottom 66" (168 cm) pieces perpendicular to all the other holes (note: 4 additional holes will need to be drilled later in the construction process, into the top length pieces, toward the back of the trap.) These holes are drilled later in the construction process to facilitate proper placement of the holes in order to adequately match the drill hole to the exact position on the support bars.

On the width bars of the trap frame, drill holes 3/4” (19 mm) from the ends of 34” (864 mm) pieces and drill holes 2 ½” (64 mm) from ends of the 34” (864 mm) front pieces. Additionally, drill two ¼” (6 mm) holes 2” (51 mm) apart in the middle of the top front 34” (864 mm) bar, as these holes are used later for the trigger assembly. On the frame tubing that will become the side support bars, drill holes 3/4” (19 mm) from the ends of the 24” (610 mm) and 50” (127 cm) pieces. On the 50” (127 cm) side support bar pieces, drill four, ¼” (6 mm) holes, at 3” (76 mm) spacing starting at 16” (406 mm) from bottom, perpendicular to the end holes. These drilled holes are used for adjusting the height of the trip string as required once the trap is set in the field.

Assembly of the trap requires a minimum of two people. Initially, lay out the tubing frame lengths, widths, and uprights into a configuration that allows for easy attachment. Place the two uprights, with support bar holes, in opposite corners. Place the 2 length pieces of the frame with the I-bolt holes in the top position and the 2 length pieces of the frame with the support bar holes in the bottom position, ensuring the rat trap support holes are positioned to the back of the trap. Run the 3/8” (10 mm) bolts from the inside of the trap out and hand tighten the bolts to form the basic frame of the trap. Attach the length pieces of the frame to the outside of the uprights into the end holes. Attach all width pieces of the frame to the outside of the uprights, except the back bottom width bar, which goes inside. Prop the trap up, in this loose assemblage, to weave the meshing onto the bars, starting with the side and top pieces. Weave the mesh onto the bottom bar first and work the mesh upwards, up and over the top portion of the frame and down toward the other bottom bar. Weaving the mesh onto the top bars is important to ensure animals do not get caught up between mesh and bars. The back end and side meshing will need to be weaved to the uprights and width bars simultaneously. In the corners, the meshing should go outside of the bolts in order to hold the mesh in place. After the mesh weaving around the frame is complete, tighten all bolts, expect for the front top width tubing bolts, ensuring the trap is sturdy but still collapsible.

Attach the four support bars to the already drilled holes on the uprights (corner supports 24” [610 mm]) and bottom length frame bars (50” [127 cm] supports). Square off the trap and raise the support bars to the top length and mark the spot for drilling the holes for attachment. The placement of the support bar drill holes should be approximately 14” (356 mm) and 20” (508 mm) from the back of trap on one side and approximately 15” (381 mm) from the back and 14” (356 mm) from the front on the rat trap side. Use the 3” (76 mm) square locking pins to hold the supports to the top bar with the detachment to the outside so the bar can by knocked off easily by the animal movement in the trap without injury. Use cable ties to attach the locking pins to the trap so they do not get lost during transport and capture.

With respect to the door assembly, weave the door mesh to the front top width. From the top down, weave the door uprights loosely through the door mesh into every second square and weave the drop-door weight bar through the bottom of the door mesh.

Depending on the cut of the mesh, a square or two may need to be cut away to fit the mesh over the steel rings. Attach the uprights to the upper and lower widths and test the mesh door to make sure it moves and drops down easily. Ensuring the door will easily fall and drop with the appropriate weight is important so captured deer cannot escape through a front trap door that does not fall properly. Tighten all bolts on the door assembly snuggly.

The present research used both an s-hook (VerCauteren et al. 1999) as well as a rat trap trigger system. Both trigger systems were used with success. The rat trap trigger assembly requires the attachment of the rat trap to the appropriate top left length frame bar using the predrilled holes, and securing the trap to the frame using with shorter 2 ¼” (57 mm) bolts (Photo 3.1). Drill 2 holes into the rat trap about 1 1/2” (38 mm) from the side, in order to align the trap with the holes on the bar. Additionally, drill a ¼” (6 mm) hole directly under the trap dog-down lever in order to run the trip string through it. Next, attach the trip string I-bolts to the support bars and also attach the trigger string guide I-bolts to the top of the frame length bar and front width bar above the door. Further, attach the four I-bolts to the four top corners of the trap, which will be used for the tie down straps. Cut the trip string and trigger string to appropriate length for the trap as required.

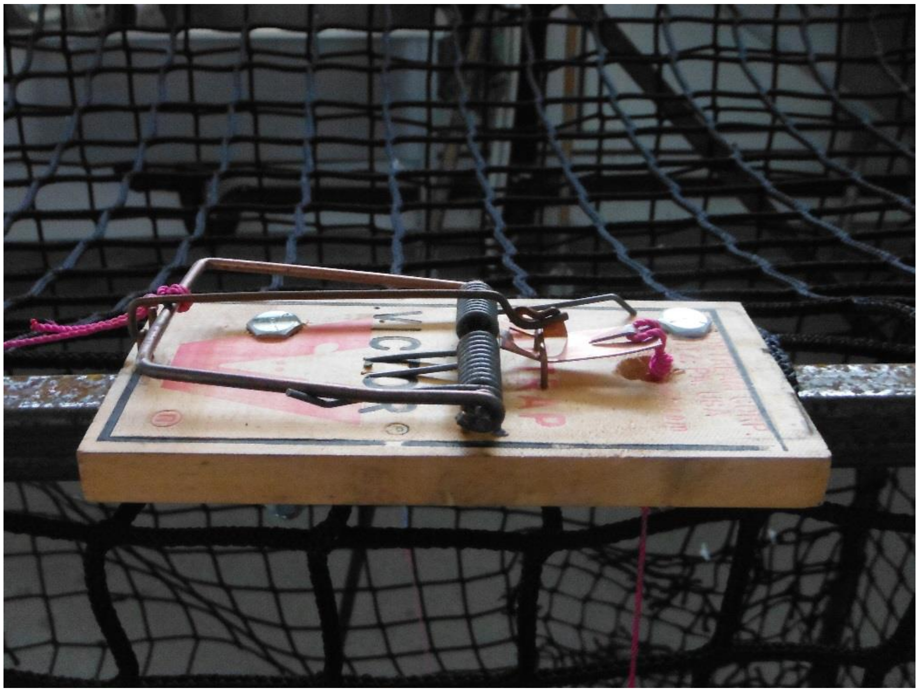


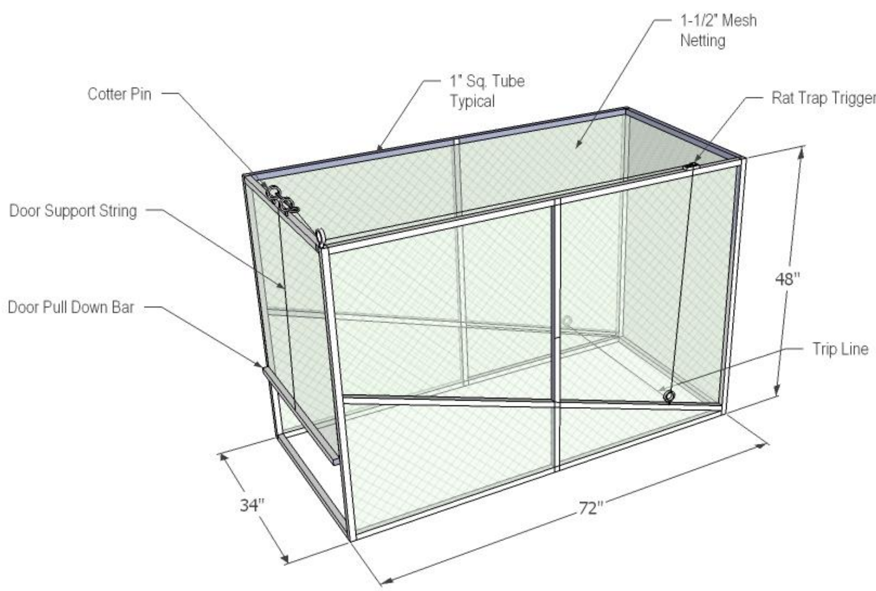
Photo taken by: E.C.McCance

Photo 3.1: Rat Trap Trigger

The trip string should have 1” (25 mm) loops at both ends and be approximately 70” (178 cm) in total length. Run one end of the string with a loop up through rat trap hole under the dog-down lever and attach the string loop to the dog-down lever. Run the string down to the support bar I-bolt (on the left side of the trap) and then through trap, creating the portion of the trip string the animal will knock when in the trap. Proceed to run the string across the inside of the trap to the other support I-bolt on the other side of the trap opposite to the rat trap trigger and use a paperclip to attach the trip string to the support bar I-bolt. The present research used the paper clip successfully, given that the paper clip is flexible enough to be pulled down by the animal after the trigger is sprung.

The trigger string should have 1” (25 mm) loops at both ends and be approximately 60” (152 cm) in total length. Attach the trigger string loop to the rat trap striker and run the trigger string through the two I-bolts up to the front corner of the trap and along the front of the trap to the top middle of the front door width I-bolts. Attach a 3” (76 mm) cotter pin to the end loop. It is important to allow for slack in this string between the striker spring bar and the cotter pin to allow the rat trap to gain enough momentum to pull the cotter pin free from the weight of the drop-door. Test the trigger string and trip string repeatedly.

The door release string should have 1” (25 mm) loops at both end and be approximately 20” (508 mm) in total length. Attach to the top width door frame and run from inside of the door under the mesh and Drop-door weight bar. The other loop of the door release string will be used between the two I-blots on the door width. Use the cotter pin through the door release string loop to hold the door up when the rat trap is set for action.



3D Image by: W.Carson McCance

Figure 3.1: 3D Image of Modified Clover Box Trap

3.5 Trap Placement, Timing, Baiting, and Handling

3.5.1 Urban Cage Trap Placement

Within an urban environment, finding a suitable and safe trapping location can be challenging. Capture and handling within city spaces with high human population density and a maze of road networks presents safety challenges for both people and deer. Trap locations should be selected far enough away from roadways and walking trails that they can be effectively concealed and that disturbance around the trap can be minimized. Trap placement must consider safe deer escape routes, thus reducing the risk of a post-captured, stressed deer running out onto roadways and being involved in a deer-vehicle collision (DVC). To maximize success, traps should be placed in high deer activity areas, including trails between bedding and feeding areas (VerCauteren et al. 1999).

Property ownership within urban spaces can present complications to the location of ideal trapping sites. Finding public property within the heart of residential space, property that represents high levels of deer activity and that meets the suitable and safe trapping site requirements, can be difficult. Private residential properties offer possible suitable trapping locations; however, finding properties that are large enough to conceal trapping activities, and to provide suitable escape routes for deer without barrier fencing and other obstructions is challenging. In addition, while one property owner may be on board and supportive of the research and allow capture activities on his or her property, neighbors may not be, resulting in conflict associated with the research.

3.5.2 Urban Cage Trap Set-up

Cage traps used for physical immobilization of deer are anchored to remain upright during capture and handling. Ideally, cage traps should be placed in a small open area with four solid trees or other objects located near the four corners of the trap. The site where the trap is placed should be cleared, paying particular attention to any braches poking up that could result in injury to the deer and/or handlers. The trap should be placed in such a way that the trap door faces the direction that the handlers will approach (VerCauteren et al. 1999), driving the deer to the back of the trap, and allowing enough room for handlers to enter the front of the trap to physically immobilize the deer. The four top corners of the trap should be firmly anchored (ratchet straps are effective), to the base of four solid trees (if available), or anchored to stakes driven into the ground near the four trap corners. For the safety of both the handlers and the captured deer, ensuring that the four top corners of the trap are firmly anchored and the trap is solid against the ground with little or no side-to-side movement, is important when physically immobilizing deer. Handlers should be cautious of the direction of the trap door to ensure that post-captured deer are released in a clear and safe direction, void of heavy human-activity areas, fencing, buildings, or busy roadways. A clearing should be present in front of the trap, as VerCauteren et al. 1999 note, of at least 15 m, to reduce the likelihood of deer injury upon release.

Traps can be repeatedly set in the same location until the success of capture begins to decline. In our experiences, after 2-3 active trapping nights, trap sites became stale. Similar to the findings of VerCauteren et al. (1999), however, by moving the trap slightly, trapping success is increased.

Photo taken by: E.C.McCance

Photo 3.2: Cage Trap

3.5.3 Urban Capture Timing

Trapping activities are most successful in northern latitudes during winter months, between December and March, after the rut, yet before does enter their third trimester of pregnancy (VerCauteren & Hyngstrom 1998). During this time, deer are food stressed and most easily captured. Capturing during the cold (on average, during this research, trapping night temperatures fell between -15 to -20 degrees Celsius, but no colder than 25 degrees Celsius, the temperature at which capture activities were halted) and dark months, which characterize the winters in northern latitudes, is beneficial in an urban environment in that it reduces the amount of outdoor human activity in and around trapping locations.

Integral to city spaces are relatively high levels of human activity, lights, loud noises, traffic, and dogs. While it is likely that urban deer are habituated to these conditions, trapped deer exposed to these disturbances are likely subjected to increased stress. In an effort to reduce unnecessary stress to the captured deer, we opted to limit capture times during daylight and restrict our capture efforts to times between dusk and dawn. Further, despite research suggesting that traps within a forested landscape need to be checked only twice within 24 hours (VerCauteren et al. 1999), I tightened the frequency within which I checked the traps, this in order to reduce the timeframe captured animals were confined and exposed to higher risks of disturbance present within urban spaces. In combination with concerns over reducing the stress experienced by captured deer, were considerations for the perceptions of urbanites potentially exposed by happenstance to captured animals. Therefore, each evening trap was set at dusk and checked between 8:30-9:00 pm, again at 11:30-12:00 pm, and finally between 5:30-6:30 am, after which, the traps were secured open and left unset for the remainder of the day.

3.5.4 Urban Cage Trap Bait

Domestic livestock foods are the most common baits used in big-game trapping (Schemnitz 1996). Pre-baiting traps is a necessary component of any trapping program; however, researchers conducting deer movement studies should be mindful that their pre-baiting is not conducted over a lengthily timeframe, thus heavily influencing deer movement, and resulting in potential home range shifts. An unfortunate downfall of using capture methods that require bait is that attracted animals must be lured to bait, thereby depending on the objectives of the research, biasing the study animals to an artificial food source. Our experiences suggest that pre-baiting in areas with high-deer activity levels is not required more than 24-48 hours prior to capture. During our capture program, sweet feed (an intended horse feed primarily made up of barley, oats, and corn covered with molasses) was the most effective bait used. I did not have much success with the use of salt/salt blocks, even in early spring, possibly due to the increased availability of artificial supplies of salt already found in generous quantities within an or northern urban environments where salt is used to melt ice and improve driving conditions on roadways.

During the days prior to capture, traps should be placed on site and tied open, allowing the deer to become acclimatized to their presence. The traps should be baited and deer should be allowed to move freely in and out of the trap to access bait. Small bait piles should be placed outside of the trap, with a small trail of bait leading into the trap. Researchers should be careful not to supply large amounts of bait outside of the trap reducing the need for deer to access bait within the trap. A larger bait pile should be placed at the back of the trap, behind the trip string location, but far enough away from trap sides that the deer cannot access the food from the outside. Once deer are frequently on the bait, moving in and out of the unset trap, capture activities should commence. If deer are not using the bait frequently after several days, researchers may want to consider moving the trap slightly or selecting a new trap location.

3.5.5 *Deer Handling: Physical Immobilization*

In situations where chemical immobilization may not be feasible or warranted, manually restraining deer can be a very quick and effective method for affixing ear-tags and research collars (VerCauteren et al. 1999). Manual restraint should involve 2-3 handlers. Members of the capture crew and the primary researcher attended a multi-day capture and handling course at the Wildlife Science Center in Forest Lake, MN (http://www.wildlifesciencecenter.org/). As handlers approach an active trap, a threshold exists within which the captured deer becomes aware of the handlers presence, and generally the activity level of the deer confined within the trap increases. As the handlers cross that deer awareness threshold, they should move as quickly as possible toward the trap and enter through the trap front door. Handlers should avoid hesitation and enter the trap with confidence in order to reduce the opportunity for un-controlled activity within the trap. Upon entering the trap, the first handler should pin the deer to the back of the trap, bear-hugging the animal, using the handler's body weight over top of the animal's back, tucking the deer's front legs up underneath its chest, and lowering the deer toward the ground. During this time, the second handler should enter the trap and assist in lowering the deer safely to the ground while carefully controlling the position of the deer's head and neck. Handlers should be cautious of the deer's hind legs and position themselves behind the deer's body opposite of the hind legs, being prepared that the deer may use power in its legs to push upwards. The time between the deer's awareness of the handlers presence in the vicinity of the trap to the time when the deer is safely immobilized within the trap, represents the most precarious timeframe of the capture, with the highest risk potential for injury and deer failing from exhaustion. Handlers should work efficiently to reduce this timeframe as much as possible and quickly establish a control hold over the deer for the safety of the deer and crew.

Once safely restrained, the deer is blindfolded. A winter neck warmer or a portion of a sweatshirt sleeve make for efficient blindfolds. In the case of our urban deer research objectives, the timeframe required to work with restrained deer was minimal, and therefore, hobbles were present but not used unless necessary. Specific to our urban deer capture plan, once restrained, the deer were blindfolded, basic measurements were taken, an ear tag was affixed, the collar was fitted, the blindfold was removed, and the animal was released in a safe direction. The timeframe from the moment of the deer's awareness of the handlers' presence in the vicinity of the trap, to the point of release was on average between 3-5 minutes. During the course of the research, the capture team handled both non-antlered and antlered bucks in the Clover box traps. In our experiences, antlered males were easier to handle than non-antlered males. The antlers provided handlers with an improved efficiency to establish control of the buck's movement and stabilize its head and neck. In a majority of the cases where antlered bucks were restrained within the Clover box trap, there were no issues with the antlers becoming tangled in the trap mesh; however, in the case where the antlers did become entangled ($n = 1$), capture crews removed (time <5 minutes) the antlers from the netting using antler cutters.

Occasionally, released animals immediately drop to the ground, attempting to remove the GPS collar with their back hooves. In these cases, where possible, handlers would assist the collared deer back onto their feet and safely re-direct them.

3.6 Conclusions

Capture and collaring of WTD in urban environments with high human population density presents numerous challenges. Urban residents have diverse attitudes and perspectives with respect to wildlife and associated research. Wildlife managers and researchers working within these developed spaces need to consider a variety of unique factors. Critical to an urban deer collaring program is careful consideration of collar type, weight, and volume; trap specifications tailored to the method of capture and to the geographic location; and a number of distinct criteria specific to capture and handling of deer within urbanized spaces. Attention to these key components early on in an urban deer collaring program may assist wildlife managers and researchers in mitigating public concern and enhancing the safety and success of the collaring program.

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CHAPTER FOUR

IDENTIFYING HOW HUMAN BEHAVIOR INFLUENCES URBAN WHITE-TAILED DEER MOVEMENT PATTERNS IN A CANADIAN METROPOLITAN AREA

4.1 Abstract

Using a critical case study approach, this research investigates, by way of one-on-one personal interviews, the wildlife value orientations and emotional dispositions associated with the human behavior of intentionally supplying artificial food sources for urban deer. The results of this research illustrate the influence of human behavior on urban deer movement, thereby adding to our understanding of the nature of human-deer interactions in a city, and the increasing potential for human-wildlife conflict and human-human conflict within city spaces. The study highlights the need for, and challenges involved in, an integrated approach to urban wildlife management, an approach that supports species co-existence within the complex dynamics of modern metropolitan spaces.

4.2 Introduction

Urban white-tailed deer (WTD) (*Odocoileus virginianus*) provide a good case study of the increasingly complex human-wildlife problems faced by contemporary wildlife managers. Many urban centers throughout North America are experiencing growing urban WTD populations (Brown et al. 2000; Doerr et al. 2001; DeNicola et al. 1997; McDonald et al. 2007; Kilpatrick et al. 2007). Urban and suburban areas offer a mixture of open space, green ways, utility rights-of-way, and commercial development that provide suitable conditions for WTD (Raik et al. 2005). The highly resilient and adaptable nature of WTD contributes to their ability to survive in human-altered landscapes. WTD have been successful in their capacity to adapt and thrive in urban, metropolitan environments. They find refuge in urban centers due to hunting restrictions, firearms discharge laws, and minimal predation (Adams et al. 2006; Conover et al. 1995; Messmer et al. 1997). Growing WTD populations along with hunter accessibility limitations, and conflicting social attitudes and perceptions concerning wildlife, have resulted in increased deer densities throughout most of their North American range (Brown et al. 2000; DeNicola et al. 1997; Kilpatrick et al. 2007; McDonald et al. 2007; Merrill et al. 2006). Urban environments provide WTD with adequate shelter, available water, and both natural and human-supplemented food sources (Adams et al. 2006). These factors, coupled with a high birth rate (Adams et al. 2006; DeNicola 2000), have resulted in increasing WTD populations in largely human populated areas.

Especially in urban areas, WTD can cause property damage and present a human health and safety concern (Decker & Gavin 1987). They eat ornamental trees, shrubs, flowerbeds, vegetable gardens and fertilized lawns (Conover 1997; Swihart et al. 1998; VerCauteren et al. 2005). WTD are a host to a number of transmittable diseases, such as Lyme disease. WTD also pose a significant human safety concern, and are involved in an increasing number of motor vehicle accidents. Deer-vehicle collisions (DVCs) represent a human-wildlife conflict of serious concern as they may result in significant risk to human life and safety, deer mortality, and vehicle damage (Finder et al. 1999).

The Greater Winnipeg Area (GWA), like many other North American metropolitan centers, has experienced a growth in WTD populations over the past two decades (Hagglund 2006) (see Figure 5.1). With the increase in the urban deer population, an increase in the number of human-deer conflict cases has been reported. Manitoba Conservation and Water Stewardship (MCWS) has noted a significant increase in the number of complaint calls involving human-deer conflict within the GWA over the last 20 years, represented in Figure 4.1 (MCWS unpublished data, Winnipeg District Occurrence Report). This increase in complaint calls is positively correlated to the increase in the number of WTD residing within the urban area. The most pervasive negative impacts identified through the investigation of resident opinions and tolerances toward the GWA urban deer population are damage to residential plantings and DVCs (McCance 2009).

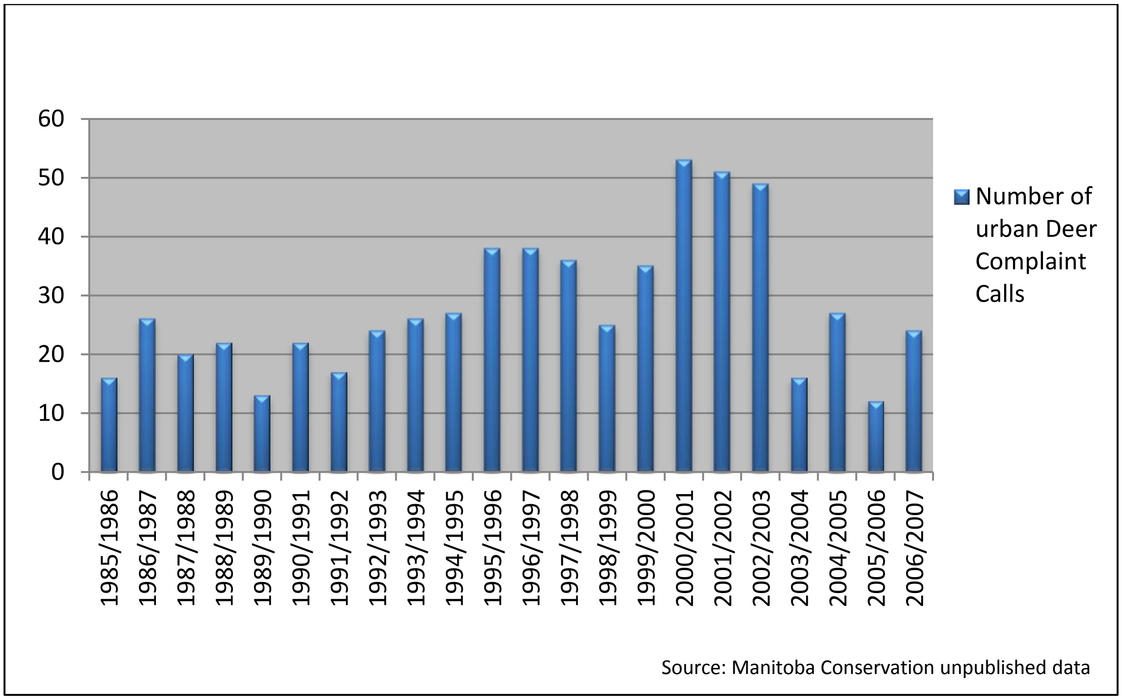

Figure 4.1: Annual Number of Complaint Calls involving WTD in Winnipeg

Despite these potential conflicts, a majority of GWA residents enjoy having deer within their communities (McCance 2009). A random, broad-based survey conducted in 2008 confirms that a significant number of GWA residents admit to attracting WTD to their property by providing artificial food sources (McCance 2009). Such action may be exacerbating the two most pervasive negative impacts identified by GWA residents as well as cultivating a higher deer population density than might occur otherwise. Residents providing artificial food sources to deer may lead to food conditioning and habituation. Habituation of wildlife, resulting in the lack of an animal's behavioral fear response to the presence of humans after repeated non-consequential encounters, can create uncertain and risky situations that lead to negative human-wildlife interactions and thus human-wildlife conflict (Hudenko 2012). Human decisions and behaviors influence whether habituation and human-wildlife interactions will result in negative outcomes for both people and wildlife (Hudenko 2012). Wildlife managers are called upon to reduce human-wildlife conflict. Therefore, understanding what drives human behavior and decision-making may aid in the management of these complex issues.

4.3 Objectives

As part of a larger study, the researcher investigated WTD movement in the GWA relative to roads, as well as other spatio-temporal aspects of habitat use. This investigation suggested that collared urban deer in the GWA spend considerable amounts of time in close proximity to a select number of residential properties (see Chapter 2).

Coupled with this human dimensions study, a comparative analysis of deer movement patterns between a rural location, Riding Mountain National Park (RMNP), and the GWA, allowed for the exploration of the spatial variation and movement pattern differences. This enabled a better understanding of the variables, such as resident behavior, habitat types, and land uses that may be influencing urban deer movement, to be determined. Spatial analysis of these two cohorts indicated that urban WTD have significantly smaller home range size than WTD residing in RMNP (see Chapter 2).

Through this larger research initiative, analysis of collared deer movement identified the urban deer to be frequenting a select few residential properties on numerous occasions, travelling across busy roadways multiple times a day. Such movement across roadways to frequent these select few properties increases the risk of human-deer conflict in the city, most notably, the occurrence of DVCs (see Chapter 5). Through personal, one-on-one, open-ended interviews, the researcher investigated whether these residential properties are associated with the social behavior of providing an artificial food source to urban deer. For the purpose of this research, an artificial food source is defined as one that is intentionally placed to specifically attract and feed deer. The human behavior of providing artificial food sources influences the nature of human-wildlife interaction within the GWA and in turn prompts a potential increase in human-wildlife conflict occurrences. These artificial food sources affect the urban WTD herds' natural population balance, natural behavior, and natural movement patterns.

In response to the above-noted findings, using a critical case study approach (Patton 1990), the researcher set out to investigate the wildlife value orientations and the emotional dispositions that are associated with the human behavior of providing artificial food sources to urban deer so as to better understand this specific behavior through the eyes of the resident (Sarantakos 2005).

4.4 Conceptual Framework

4.4.1 Wildlife Value Orientations

Many studies have investigated human dispositions toward wildlife by concentrating on such cognitive factors as attitudes, beliefs, norms, values or value orientations (Purdy & Decker 1989; Bright et al. 2000; Deruiter 2002; Zinn et al. 2002; Hunter & Brehm 2004;

Whittaker et al. 2006). Yet, the definition of such terms as values, attitudes, and beliefs varies. For the purposes of the present research, the definition of values provided by Fulton et al. will be followed, that is, the definition of values as first-order cognitions that are few in number and stable (Fulton et al. 1996). Manfredo & Dayer, among others, provide similar definitions of values, describing them as fundamental, deeply rooted, slow to change; values are often formed early in life by family teachings, cultural learnings, and religious beliefs that are tied to one's identity and signify modes of conduct or qualities of life that are held dear (Peirce et al. 2001; Manfredo & Dayer 2004; Whittaker et al. 2006). An individual's values influence his or her wildlife value orientations.

In order to understand wildlife value orientations (as defined by Kellert 1996), a general understanding of cognitive hierarchy is useful (Vaske & Donnelly 1999). The cognitive hierarchy framework illustrates the relatedness of value orientations and attitudes and norms which ultimately influence behavior (Manfredo 2008). Figure 4.2 depicts the relationship between value orientations and behavior and how these cognitions can be organized into a hierarchy with values and value orientations as fundamental, influencing attitudes and norms, and in turn behaviors, shown here as an inverted pyramid (Vakse & Donnelly 1999).

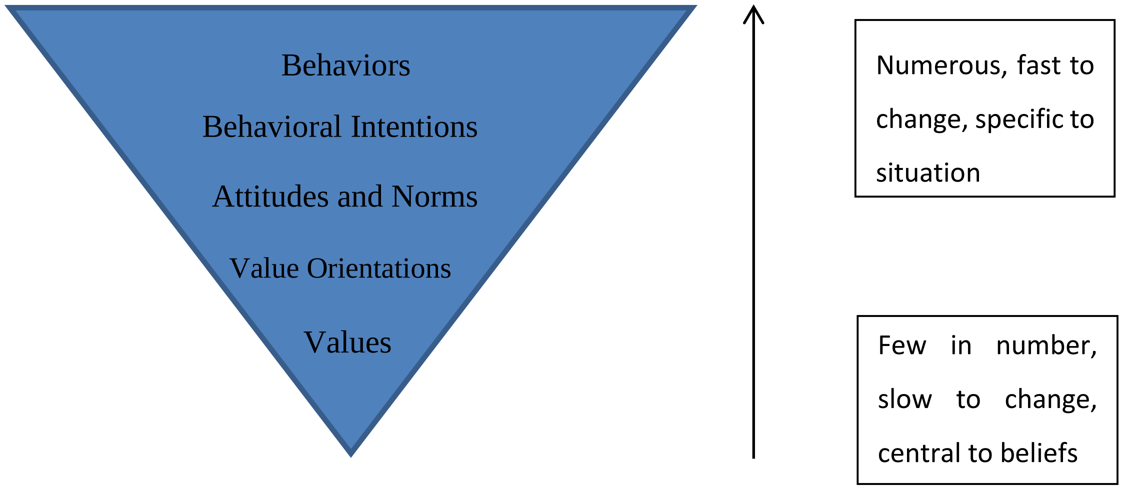

Figure 4.2: The Cognitive Hierarchy (Vaske and Donnelly 1999)

Wildlife value orientations represent an individual's basic patterns of beliefs about wildlife use. The present study assumes that value orientations, as Kellert 1996 defines them, influence an individual's attitudes and inevitably behaviors toward wildlife. In turn, one's behavior influences the nature of human-wildlife interactions. Kellert identifies nine basic value orientations that can be attributed to nature and/or wildlife; these are represented in Table 4.1 (Kellert 1996). Kellert defines these value orientations as ranging across a spectrum of different positions such as humanistic ("love" for all aspects of nature) to dominionistic (total mastery, physical control, dominance over nature). Within this spectrum, individuals may exhibit an orientation within one value category while expressing sentiments that reflect their orientation toward other value categories (Hunter & Brehm 2004; Manfredo & Dayer 2004). This research proposes to investigate the wildlife value orientations of GWA residents who provide artificial food for urban deer and associate these findings with Kellert-defined value orientations.

Understanding individuals' wildlife value orientations is important given that their wildlife value orientations influence their attitudes and in turn their behaviors. Thus, an individual's behavior toward wildlife is in part propelled by specific attitudes which are guided by their wildlife value orientations (Teel et al. 2007). Of importance to note, however, is that, while cognitive theories such as theory of reasoned action (TRA) and theory of planned behavior (TPB) (Ajzen & Fishbein 1980) suggest that attitudes and subjective norms influence people's intentions to perform a certain behavior, there are other factors beyond the cognitive, such as emotions, that are important to consider and play a role in shaping human behaviors and the decision-making process (Hudenko 2012).

For the purposes of this research, an attitude is defined as an individual's tendency or orientation, either favourable or unfavourable; his or her manner, disposition, feeling, or position with regard to another person, concept, action, or thing (Manfredo, 2008). It is important to understand the beliefs held by an individual (or community) shape their wildlife value orientations, since these can influence social behavior (Manfredo 2008). Complicating matters further, social norms are also important and can influence social behaviors. Social norms are standards of behavior shared by the members of a social group. Social norms suggest what people should do, or what most people of a collective group are doing (Peirce et al. 2001). Social norms tend to draw the behavior of the collective toward the average or the "normal" disposition (Heberlein 2012). Social norms are shared beliefs about the acceptability of an action and are highly situational (Zinn et al. 2000). Therefore, understanding the role of social norms is an important component so managers may be better able to predict behavior.

This research explores the wildlife value orientations of the interviewed GWA residents in order to investigate how these value orientations are associated with the social behavior of providing an artificial food source to urban deer. Through this social behavior, the nature of human-wildlife contact is defined, urban deer movement is influenced, and in this case, the risk of human-wildlife conflict is increased (see Chapter 5). Information on the wildlife value orientations associated with this behavior can provide managers with guidance for structuring effective prevention, management, education, and participation strategies (Manfredo & Dayer 2004).

Table 4.1: Basic Values Orientations Attributed to Wildlife and Biodiversity*

Value	Definition
Humanistic	Strong emotional attachment and "love" for aspects of nature
Naturalistic	Direct experience and exploration of nature
Ecologistic-Scientific	Systematic study of structure, function, and relationship in nature
Aesthetic	Physical appeal and beauty of nature
Symbolic	Use of nature for language and thought
Moralistic	Spiritual reverence and ethical concern of nature
Utilitarian	Practical and material exploration of nature
Negativistic	Fear, aversion, alienation from nature
Dominionistic	Mastery, physical control, dominance of nature

* Source: Kellert 1996, 38

4.4.2 Emotional Dispositions

Further to mental cognitions and social norms, emotional dispositions influence human behavior toward wildlife. Animals evoke strong human emotions that can be both positive and negative in nature. Human-wildlife interactions are typically emotionally-charged events (Hudenko 2012). Recently, scholars have begun to focus on human emotions toward wildlife and to explore the role emotions play in influencing human behavior toward wildlife and human-wildlife interactions (Jacobs 2009; Hudenko 2012; Jacobs, Fehres, and Campbell, 2012; Jacobs et al. 2012). Without question, the study of human emotions is complex. Scientific evidence suggests that measuring a person's emotional state is one of the most vexing problems in affective science (Mauss & Robinson 2009). In order to be comprehensive, the measurement of emotion requires the investigation of emotions across a number of fronts (physiological, brain activity, behavioral, and self-reported) (Jacobs et al. 2012). The investigation of human emotion can focus either on the discrete perspective of emotions or on the dimensions perspective on the nature of emotions. The discrete perspective measures emotional states such as happiness, joy, anger, or fear. The dimensions perspective measures emotional states within a theory of general dimensions such as valence (liking/disliking), arousal (activation-deactivation dimension), or approach-avoidance (Mauss & Robinson 2009). As Darwin (1965) suggests, emotions are an evolved communicative function that instructs behaviors that reveal one's emotional state toward others. Based on this theory, one's emotions are closely tied to one's behavior.

Many of our automatic emotional bodily responses are shared with animals and we are able to recognize their emotional expressions as closely related to our own. The human tendency to anthropomorphize animals and to create human-wildlife interactions could be partially explained by our perceived ability to recognize in animals emotional responses similar to our own (Jacobs 2009). The present research focuses specifically on discrete emotions measured through self-reporting, identified during the one-on-one personal interview process in relation to the behavior of artificially feeding and attracting urban deer to their property. Within this context, this research does not embark on a comprehensive measurement of human emotion but rather attempts to provide insights into the self-reported discrete emotions expressed by the respondents.

4.4.3 Personal Characteristics

Numerous studies have shown that individuals with certain common personal characteristics tend to hold in common certain attitudes with respect to wildlife and acceptable wildlife management strategies. Religious affiliation, sex and gender, age, and cohort (urban vs. rural (agricultural) upbringing; from hunting/fishing parents/grandparents; among others) all influence individual values and behavior toward wildlife. Manfredo suggests (Manfredo et al. 2003; Manfredo 2008) that increasing affluence, education, and urbanization have resulted in a shift in attitudes from a traditional utilitarian focus to a protection orientation with respect to wildlife. These findings suggest that personal attributes may play a role in influencing social behavior. These factors should be mentioned as relevant in their influence of an individual's mental cognitions toward wildlife. Building on the model of the theory of reasoned action (Ajzen & Fishbein 1980), Figure 4.3 presents a model that ties the concepts of emotion dispositions and mental cognitions together to illustrate how each relates to the other, helping us better predict human behavior toward wildlife.

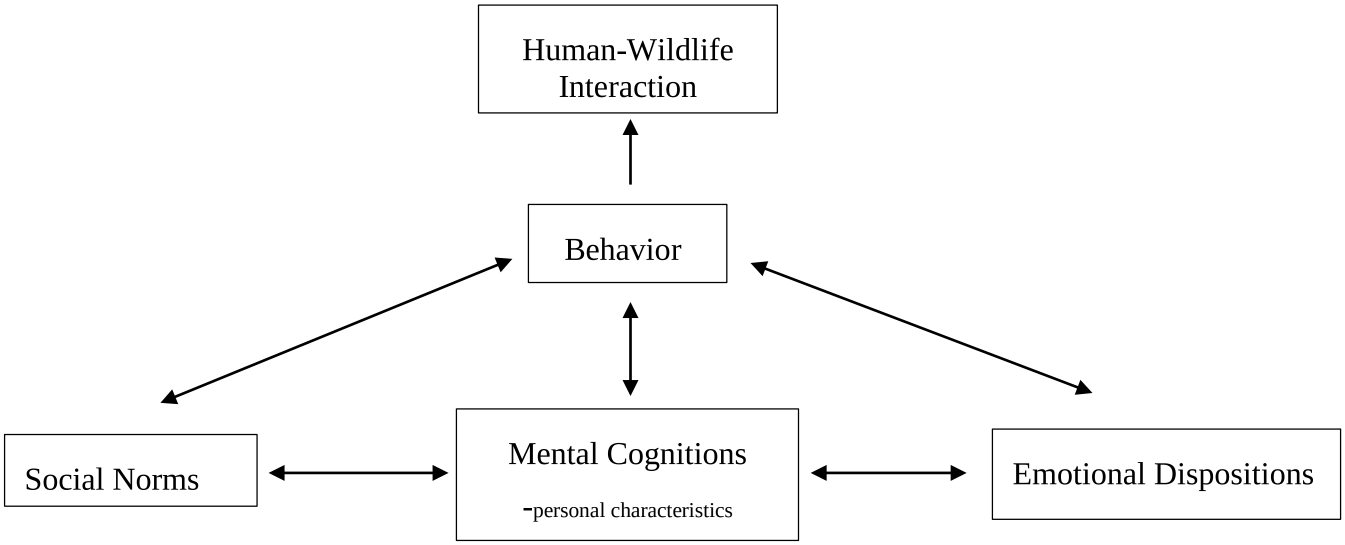

Figure 4.3: Model Predicting Factors that Influence Human Behaviors toward Wildlife (adaptation of Ajzen & Fishbein 1980 model)

4.5 Methods

4.5.1 Data Collection

The spatial movement analysis gathered from the researcher's investigations of WTD movement within the GWA was used to identify residential properties where collared urban deer spend a considerable amount of time. Spatial data acquired from deer that were collared for a minimum period of six months was used to determine potential GWA residents to be interviewed. Within ArcGIS 9.3, a spatial join was conducted to relate the deer location data to the land use types in order to assess the land use types where most deer locations occurred. Spatial data from the collared deer were isolated to show deer movement on residential property and the GWA residential property that showed the greatest density of deer Global Positioning System (GPS) location points/square meter for the first six months the deer was collared was identified. All collared GWA deer that survived for a minimum of six months after being collared were used to select a GWA resident to be interviewed. The residential property owners showing the highest density of deer location points/square meter were approached and asked to participate in an interview. The household was initially contacted by mail (using a modified version of Dillman methodology) and provided with a letter explaining the nature of the research and asking the resident if s/he would be willing to participate (Dillman 2007). The letter requested that the resident within the household who was over 18 years of age and whose birthday was next to occur, be the individual who would participate. Two weeks following the letter being mailed, the residential household was contacted by phone by the interviewer to determine if s/he was willing to participate and if so, to set up a suitable time to conduct the interview. Resident addresses and phone numbers were acquired through Canada 411. See Appendix B for a copy of the letter sent to GWA residential households selected for this research. See Appendix C for a copy of the guiding questions for the one-on-one personal interviews. The human dimensions component of this research was approved by the Joint Research Ethics Board under Protocol number J2009:116 Appendix D, and animal ethics approval was provided by the Fort Gary Campus Protocol Management and Review Committee under the Animal Care Utilization Protocol number F09-034 Appendix A.

This inquiry seeks to better understand human actions and behaviors through participant observations and in-depth interviews, among other means, in order to produce descriptive data, from peoples' own spoken words and observable behavior (Taylor and Bogdan 1998). In-depth personal interviews generate insights into human behavior by considering what people say and do as a product of how they define their world and construct their realities (Taylor and Bogdan 1998). As Patton (1990) points out, one-on-one, personal, in-depth interviews can focus on relatively small samples, even a single case (n=1), selected purposefully. The logic of purposeful sampling lies in the selection of information-rich cases, from which one can learn a great deal about issues of central importance to the research and that are thus studied in depth. While the study of one or a few select cases does not allow for broad generalization to all possible cases, logical generalizations can be made from the weight of the evidence produced in studying even a single, critical case (Patton 1990).

The personal in-depth interviews associated with this research were conducted using just such a critical case study approach (Patton 1990). Critical cases are those that can make a point, quite dramatically, and are for some reason particularly important. As in the GWA urban deer case, the intention of my investigation was to examine the relationship of these property owners to the problem of artificially fed urban deer and to assess the wildlife value orientations and emotional dispositions of these residents. A critical case study approach yields the most valuable information and has the greatest impact on the development of knowledge. In this research, the critical case studies locations were determined by the collared urban deer movement. Importantly, the collared animal thus "selected" or determined the GWA residents to be approached and interviewed.

The interviews designed for this research followed a semi-structured format constructed of a series of pre-established, guiding, open-ended questions. The interview guideline posed by the interviewer used a directive style (Denzin and Lincoln 2003). The pre-established guiding questions framed a general direction for the conversation and provided an opportunity to pursue topics that were of specific interest (Babbie 2001). The same interviewer conducted all interviews to maintain consistency (Sarantakos 2005). Despite being semi-structured, the interviewer allowed the conversation to be open, flexible, and encouraging, to offer respondents the ability to develop interest threads that might provide evidence of meaning they assigned to their actions and that might allow for potential trends and patterns to emerge during the interviews (Sarantakos 2005). The interviewer returned to the pre-established guiding questions only once the participant had completed a thought/interest thread. Interviews and observations were documented both by the interviewer taking detailed notes of what was observed (including non-verbal response and communication) and through the use of a tape recorder.

4.5.2 Data Analysis

The open-ended interviews and observations were analyzed through thematic content analysis (Taylor 1990). Interview notes and recordings were cleaned, transcribed, and coded for themes related to learning. In this respect, the study used inductive analysis, allowing the patterns, themes, and categories of analysis to emerge from the data itself rather than being imposed prior to data collection and analysis (Taylor 1990). Key phrases and ideas specific to value orientations and emotional dispositions were identified from the transcripts. Only once the themes were identified, did the author work to match emergent themes to statements that were reflective of a particular value orientation and a particular emotion as outline by Kellert (1996). Denzin and Lincoln (1998) suggest that during the analytical process, researchers make decisions about categorical significance, definition, and validity. Data were coded, that is, classified and categorized to determine if there are any patterns among the data that may point to a theoretical understanding of the social action (Babbie 2001). Personal characteristics reported during the interview process were also sorted and coded. Concept mapping was used to put all major concepts for mental and emotional cognitions together. The data was laid out on a "horizontal" plane, examined and categorized into meaningful clusters (Taylor 1990). LeCompte and Goetz's (1983) methodology of scan, order, review, and compare was used. This concept mapping allowed for the consolidation of ideas with respect to the conceptual framework (Trochim 2001).

4.6 Results

Fourteen of the eighteen collared GWA deer survived longer than six months after they were collared, placing them into the category of being linked to a one-on-one personal interview. A total of eleven face-to-face, in-depth interviews were conducted with adult residents within the GWA with over 8 hours and 28 minutes of interviews digitally recorded. Three properties owners did not wish to be involved in this research. The mean length of the interviews was 46 minutes. Of the eleven GWA residents who agreed to be interviewed, six admitted to providing an intentional artificial food source for deer on their property to a varying degree. Of these six self-reported feeders, two indicated they were feeding on average between 20-30 deer/day during the winter months. The food sources being provided by these self-reported feeders varied. Some supplied scraps of human food while others invested a considerable amount of time and money in supplying agricultural grains in numerous small piles or in deer troughs. Two of these feeders indicated that during fall and winter months, they would use up to two to three 25 kg bags of grain (rolled oats, corn, and barley) product per week.

Of the remaining five GWA residents who were interviewed, only two of these residents were owners of the property with the highest density of collared deer GPS location points/square meter. The other three were the property owners with the second highest density of collared deer GPS location points/square meter, as the properties associated with the highest densities were contacted but did not wish to participate in the interview process. These property owners were contacted but did not wish to participate in the interview process and may or may not have been associated with an artificial food source. GWA property owners associated with an additional three collared deer were approached to be interviewed; however, the first, second, and third property owners with the highest deer densities were contacted but these property owners did not wish to participate in this study. Of the five GWA residents interviewed who indicated they did not intentionally supply an artificial food source for deer, all reported that deer used their property for protective cover and they all indicated that they neighbored a residential property intentionally supplying artificial food sources for deer. Therefore, the movement of all eleven collared deer associated with these interviews was identified as connected to an intentionally supplied artificial food source.

4.6.1 Personal Characteristics

4.6.1.1 Gender

Of the GWA residents who were interviewed and who admitted to providing an artificial food source for deer, three were females and three were males. Of those who reported to be non-feeders, three were males and two were females. Of the two residents who admitted to providing a substantial amount of artificial food for deer throughout the year, feeding on average between 20-30 deer/day during the fall and winter months, one was female and one was male.

4.6.1.2 Place

All respondents indicated that they grew up in an urban environment; however, two of the respondents, who were identified to be individuals who do not intentionally provide food sources for deer, described residing in the outer city limits in urban-wildland fringe areas.

4.6.1.3 Cohort

Of the six GWA residents who were interviewed who admitting to supplying an artificial food source for deer, the youngest resident interviewed was 40 years of age and the oldest resident interviewed was 78 years of age, for a mean average age of 58 for those interviewed. One of the six self-reported feeders interviewed indicated that he had a Master's degree while two indicated they had attended college but not completed their diploma and three specified their highest level of education to be a high school diploma. Therefore, one of the six had education of a university graduate degree. When probed about their early life experiences with wildlife and animals, only two of the six individuals who self-reported providing food for deer had early life experiences with wildlife. The other four residents who provided food for deer all indicated that they had little to no experiences with wildlife during their youth. Three of the six who fed deer indicated they currently hunt with two of the six indicating they started hunting at a young age because their parents and grandparents were hunters.

Of those who were interviewed and who indicated they do not intentionally supply an artificial food source on their property for deer, the youngest respondent interviewed was 42 years old and the oldest respondent was 81 years of age with an average mean respondent age of 65 years old. Of the five interviewed who did not feed deer, two had high school as the highest level of education, two had university Science degrees, and one had a Master of Science degree. Therefore, three of the five respondents had an education of a university undergraduate degree or higher. When probed about their early life experiences with wildlife, all five respondents described numerous experiences with wildlife growing up. All of these participants reported being active in wild spaces from an early age. Two indicated that they were currently active outdoors but non-hunters, one married a wildlife officer and spent considerable time pursuing outdoor activities, one married a wildlife biologist, and one indicated he was an avid hunter.

4.6.2 Social Norms

Social norms can influence an individual's attitude and therefore one's behavioral intentions and actions. However, the respondents who reported supplying artificial food sources for deer also indicated that they were engaged in conflict with their neighbors over their behavior. This conflict, at the time of the interviews, did not persuade them to adjust their behavior. Conversely, those interviewed who reported they do not feed deer, expressed frustration and indicated other neighbors did also, in regard to failed attempts to get residents who supplied artificial food sources for deer to stop the feeding behavior. When respondents were asked about a potential bylaw that would prohibit the feeding of deer, five of the six feeders did indicate that they would then stop the feeding behavior and three of six indicated they feared that their neighbors would report them if they didn't.

4.6.3 Wildlife Value Orientations

Throughout the course of the interview process, respondents provided various statements that were used to identify potential themes and to ascertain whether these themes are suggestive of a particular wildlife value orientation. Out of a total of eleven interviews, six respondents indicated that they intentionally provide an artificial food source to attract and feed deer on their property. These respondents often referred to the deer as having human emotions and needs. One respondent (female, 68 years of age, feeder) said:

"It is very important to me to know that the deer are being cared for. I know each one and they know me, they need me….that GPS collar on my deer makes her [the deer] feel shame and she is embarrassed with the others because of that collar….I only wish I could do more for these deer, but (laughing) my husband draws the line at letting them into the house."

Her response to potential management options for the urban deer population was:

Leave my deer alone. The city should be creating safe places for these deer. Why should I stop feeding when drivers are not slowing down?

Similar sentiments were recorded for another respondent (female, age 78, feeder):

I have a very large yard and we have a deer feeder house that my husband built out back. We put scraps out every day. I love to watch them and take home movies of them….management should be about stopping development and it should think about what the needs of the deer are.

These respondents referred to the deer as pets (female, age 44, feeder):

I come from a city of 15 million people so I grew up in a place where we never got to see wildlife. Living here with these deer is wonderful and it is amazing to see them. We don't have any pets so it is nice for the children to have them and feed them. We talk about them all the time at the dinner table.

During the interview, a list of some of the downfalls that accompany artificially supplying food sources to deer were read and the respondents were asked whether, after hearing about these downfalls, they would change their behavior of providing food for deer. All three of these respondents indicated that they would not. One respondent cried, indicating that even after hearing those facts she didn't think she would be able to stop, that the deer were very important to her. When asked whether their behavior would change if a bylaw were passed prohibiting the feeding of deer with charges laid for non-compliance, all three respondents indicated that they "would never break the law" and "wouldn't want to do anything that was wrong".

Two of the other three respondents who had indicated they supplied food for deer indicated that they were hunters. These respondents indicated they appreciated having the deer on their property and enjoyed watching them. One respondent (male, 58 years of age, feeder):

I like having them around but no more than I like having chipmunks around, they are just one species in the system and I like to watch the system at work.

Another respondent (male, 61 years of age, feeder):

I enjoy having the deer around as I feel more connected to nature.

Both of these respondents indicated they would change their behavior once they were read some of the downfalls that accompany feeding deer saying “I see what you are saying, I never thought of that,” and “absolutely that changes my mind on feeding.” Both of these respondents indicated that they would support population control as a means to reduce deer populations in the city if that was something that was necessary in the future indicating:

I would support a cull if the meat could be used to feed some hungry people, then I am all for it.

Both of these residents provided food sources smaller in scale in relation to the portion of food other provided deer on their property and both indicated providing food gave them the opportunity to observe “nature”.

The last respondent interviewed, who indicated he did provide an intentional artificial food source for deer, also indicated he was a hunter. This respondent indicated that he provides a significant amount of food for the deer, comprising a combination of agricultural grains, vegetables, and human food scraps, and feeding on average between 20-30 deer/day during the fall and winter months. This respondent (male, 40 years of age, feeder) was particularly interesting given that he indicated he was a hunter; however, his comments suggested a desire to protect the deer. He indicates:

I love having the deer on my property. I know the character of each one and they are all different with their own personalities. I can see how by feeding them I have improved *their condition; they are in great shape now. They used to be scrawny and now their coats are nice. Even "popeye," he is an old guy with one eye that has been visiting me for years, he is doing much better since I have been feeding him.*

This resident spoke at length about his love of walking in the bush and finding antlers, so that he could identify the animal from which they had come. When the researcher read out loud some of the downfalls that accompany artificially feeding deer, this resident indicated that he didn't agree with all of these downfalls and suggested he was doing everyone a favor by saving their plantings from deer damage since all the deer were coming to his feeder. When asked whether he was in conflict with his neighbors, he said that he was doing them a favor so he didn't see the problem. When asked about management, he indicated that he didn't know the right answer and that although he was a hunter, he went out into the bush more to connect with nature than to actually harvest anything and this year he went out many times but choose not to take an animal. He indicated that now that he was feeding deer and getting to know each one as an individual, he would have a lot harder time harvesting one. In regard to the question of management he responded as follows:

I don't like development. More development will push the deer away and I want deer in my yard. It would be really hard for me to support population control as I would have a tough time saying goodbye to some of these deer that I have known for years. That would make me really sad to have to say goodbye to them. The police need to control drivers speeding and dogs off leash. This is where the focus of management should be.

This respondent did not have early experiences with wildlife.

All of the five remaining respondents (100%) who indicated they were non-feeders raised concerns over the increase in urban deer population size and the increase in human-deer conflict.

One respondent (male, 79, non-feeder) said:

I enjoy seeing the deer but things are changing, there are too many of them now and it isn't as satisfying seeing them when they are causing so much damage. I see the changes to the understory on my property, this is too much. Deer are dying on my property from car crashes, struggling around here on three legs, it isn't right.

Another resident (male, 56, non-feeder) echoes this concern and notes changes to deer behavior:

I enjoy seeing the deer but we need to keep them wild. I now have to take a stick with me when I go to take the dog out. I have had a few instances where the deer will stand their ground or even in one case move toward me. This is not typical behavior. We don't do anybody any favors by drawing them in like this.

Another resident (female, 68, non-feeder) notes:

People say let them be, but they don't see what we have seen here. Major changes have occurred to the understory in the last two decades. We watch them go by with their rib cages showing. People who feed want to be of service but they want it all to be about survival and it doesn't work that way in a natural system. Life and death are a fact and *people have to face the fear they have of death or their need to save things from what is natural.*

When these respondents were asked about how they feel about residents who were feeding deer, all expressed frustration, one calling it a "mixed up motherly instinct". Another respondent noted that the practice of feeding deer should be illegal stating:

Take feeding away and it will reduce the conflict hot spots and the animals will re-distribute; while it won't solve things, it will certainly help.

When these non-feeders were asked about their preferences toward potential management strategies, they were all open to possible population reduction; however, several noted the need for managers to be creative.

Development is a question of how much. We all have displaced something but we need to measure the impact of that displacement and weigh how much is too much. There has to be a give and take to account for the sensitivities of biodiversity, this includes all species, including humans. We need co-existence; too many people have lost their connections to nature and too many species are struggling but with co-existence comes responsibility. We need to be creative about management approaches.

4.6.4 Emotions

Human emotion can influence behavior. The sentiments expressed during these interviews provide insights into the discrete emotions that were self-reported by those who supply artificial food sources to deer and those who do not. Many positive emotions were reported by respondents who indicated they provided artificial food sources to deer. Respondents who feed were asked how they feel when they see deer on their property. These respondents described emotions of happiness, joy, comfort, delight, and love, referring to a strong connection to these animals and a need to care for and protect them. Two of the six residents who indicated that they provide artificial food for deer described a sense of belonging, suggesting that when the deer visit and feed on their property, they feel as though they are a part of their lives, connected to the deer in a family bond with them.

I love the deer and seeing them eat the food I have provided makes me feel happy. I do worry every day that something will happen to my deer. I wish somehow that I could keep them safe.

When asked if these residents had ever experienced any negative circumstances with the deer on their property, none of the feeders indicated any negative encounters between themselves and the deer. Several did mention how unhappy it made them when the deer showed aggression toward each other, resulting in a few of the residents feeling a need to create numerous feed piles to ensure each deer had his/her own food source. One resident that engages in offering artificial food sources cried while she spoke about the deer, expressing her concern and worry over their welfare.

Of those who defined themselves as non-feeders, the emotions reported, while also that of happiness to see deer, included reports of several other emotions such as anger (frustration, concern, and confusion) and sadness.

I am happy to see deer, I love wildlife but I am frustrated by what is happening. There are too many deer and nothing is being done to fix this. Why should I suffer expensive fencing costs when my neighbor is allowed to keep feeding them?

Another respondent (female, 42, non-feeder) reports:

I love the deer and get excited to see them but I recall a moment I had in the back yard with one young deer - she came up really close to me and I felt like we had a connection but that night I heard a car screech on the road and I just knew it was her. The next morning I saw her lying on the road dead. It made me sick. It is a problem.

4.7 Discussion

Overall, the results of this study do not suggest that resident gender influences whether one would engage in the behavior of providing artificial food sources for deer. Residents who reported they were not supplying artificial feed for deer had a higher level of education than those providing feed and they had more experiences with wildlife and nature from an early age than those who were supplying food. In this research, social norms did not appear to influence residential behavior as it relates to supplying an artificial food source to deer. However, social (injunctive) norms were indicated to potentially play a role if a bylaw were enforced. Heberlein suggests injunctive norms incorporate sanctions from others that can be very powerful in altering behavioral intentions (Heberlein 2012).

In this study, humanistic, aesthetic, naturalistic, and utilitarian value orientations are reflected in the sentiments of those who intentionally supply an artificial food source for deer in the GWA. Several of the residents who self-reported to be supplying large amounts of artificial food sources for deer on a daily basis had little to no experience with wildlife during their childhood and expressed strong tendencies toward humanistic value orientations. These residents struggled with the prospect of not feeding deer and the thought of losing their connection to these animals, noting that it would be very difficult for them to stop their feeding behavior.

Further, to Kellert's nine value orientations, new value orientations emerged in this research. The residents who indicated that they supply artificial food sources to deer showed strong sentiments toward ownership and possession of these animals. These residents used repeated possessive language such as "my" deer and spoke of the number of years that they had been engaged in interaction with "their" deer on their property. Since these residents had been interacting with the deer for many consecutive years on their property, despite potential concerns from their neighbors', these residents felt it was acceptable to engage in the behavior of feeding "their" deer.

A second new value orientation that emerged in this research was one of connectivity, a sense of self-belonging to a "family" unit with the deer. These residents spoke of knowing each deer individually, their character, personality, and needs. These residents spoke of emotional bonds between themselves and the deer and how they felt needed and valued by the deer. This value orientation was different than the humanistic value orientation, given the residents spoke more about their own sense of self belonging, purpose, and connectivity with the deer. They worried for the deer's welfare, were concerned about the deer's feelings, and referred to them as part of the "family". These residents spoke of the need to care and protect the deer and were frustrated that they could not do more for the deer. These findings are consistent with those of Hunter and Brehm (2004), who noted that urban dwellers with little experiences with nature/wildlife tend toward a protectionist orientation with respect to wildlife. The language used to describe the deer during these interviews was similar to the description of a domestic pet.

In the case of Hunter and Brehm's research and similarly in the case of this research, these residents did not have many wildlife-related experiences to draw on that could potentially have shaped negative emotions or attitudes toward wildlife. Table 4.2 represents the new value orientations attributed to wildlife that emerged in this research.

Table 4.2: New Emergent Value Orientations Attributed to Wildlife

Value	Definition
Ownership/Possession	Personal ownership of wildlife
Connectivity/Self-belonging	Self-belonging, purpose, strong connection and family unity with wildlife

The value orientations of the five remaining respondents who indicated they were non-feeders tended toward moralistic, ecologistic-scientific and utilitarian positions. All of these respondents raised concerns over the increase in urban deer population size and the increase in human-deer conflict. An emerging theme with respect to this cohort of non-feeding residents was cost. Cost was a common theme within all of the interviews with residents who were not providing artificial food sources for deer. These residents expressed frustration given they were not benefiting from the large numbers of deer being attracted to specific residential properties in their neighborhood yet were forced to incur the costs of expensive fencing, new yard plantings, and were subject to high risks of DVCs as a result of the unusually high congregations of deer being attracted. Given these costs and the lack of benefit, these residents questioned current civic management and policy.

Kellert (1996, 56) suggests the urban/rural distinction remains a fundamental factor in American perceptions of nature and wildlife. Individuals residing in open country areas, people who own large tracts of land, and those who farm, tend to express more pragmatic and less protectionist attitudes toward nature and animals. Although all residents in the present study grew up in urban areas, the non-feeders either grew up in urban-rural fringe areas on larger tracts of land and/or had significantly more early experiences with nature and wildlife. Those who grew up in urban-rural fringe zones with more experiences with nature and wildlife in their youth tended toward ecologistic-scientific and utilitarian value positions in comparison to those who grew up in dense city centers with little to no experiences with wildlife. The results of this research, consistent with Thomas Heberlein's (2012) conclusions suggests that public education alone ("cognitive fix") may not be enough to persuade changes in feeder behavior and that other strategies ("structural fixes") may also need to be considered in combination with educational programs, as well as effective communication messages used to enhance support for management (Campbell & McKay 2003).

The self-reported emotions expressed by respondents who feed deer were emotions of love, happiness, contentment, joy, delight, and satisfaction. These emotion suggest that these residents have strong, deeply rooted attachments to these animals. One resident sobbed as she spoke of her connection to the deer, the love she felt for them and the happiness they brought to her life every day. She cried further when describing her concern over the welfare of the deer and her worry that something bad would happen to them. Non-feeder respondents did also express feelings of joy and happiness over seeing deer however also indicated feeling frustration, concern, and anger over the lack of management and the costs they incur from resident feeders, financial and otherwise.

4.8 Management Implications

The results of this research are important for several reasons. Although the research results cannot be directly applied to all cases of urban deer feeders, they can provide us with insights into the value orientations and emotions associated with intentional feeders and non-feeders. The results illustrate that urban deer movement in the GWA is being influenced by the social action of a select number of residents who provide artificial food sources for deer. In doing so, these feeders define the nature of human-deer interaction in the city, increase the potential for human-wildlife conflict, and increase the occurrence of human-human conflict within the GWA.

Maintaining the status quo or relying on public education strategies alone to persuade these feeders to stop their behavior has been shown to be ineffective (Heberlein & Stedman 2009; Heberlein 2012). The results of this research are suggestive of the complexities that come with co-existence of species in urban areas. As urbanization increases world-wide, urban spaces that are designed for multi-species living and that support urban biodiversity will become increasingly essential. However, the results of this research highlight the need for collective urban responsibility and creative management solutions that encourage sensible co-existence principles. Furthermore, these research results are suggestive of a need to better understand the emotional and mental cognitions urbanites have toward wildlife. Management needs to be inter-disciplinary in nature and needs to explore social as well as ecological considerations to derive strategies that will be most effective at mitigating conflict.

4.9 Conclusions

Different types of experiences result in different value orientations and emotions toward wildlife. Overall findings of this research suggest that collared deer movement in the GWA is connected to confirmed cases of GWA residents providing artificial food sources for deer. This is behavior shaped both by emotional and mental dispositions. Such residential behavior determines the human-deer interactions that are taking place in the

GWA, and the behavior is tied to an increase in human-deer conflict and human-human conflict. Understanding the emotional and mental dispositions behind this behavior will assist managers to devise strategies that will be most useful to mitigate conflict.

The outcome of this investigation suggests a majority of those providing artificial feed for deer have strong value orientations toward humanistic, naturalistic, and aesthetic positions. Further, new value orientations, beyond those identified by Kellert (1996), emerged being possession/ownership, connectivity/self-belonging and family connectedness, leading to a protection orientation with respect to these animals. The residents supplying artificial feed to deer self-reported discrete emotions of joy, happiness, passion, and comfort when describing deer on their properties and their eating of the food they supplied. These participants spoke of their deeply rooted bond to these animals and were forthright that stopping their behavior would be difficult. The majority of these respondents indicated that public education alone would not modify their behaviors. A majority of those feeding deer also indicated that conflict with neighbors would not persuade a change in their behavior, while the non-feeders expressed frustration that the feeders would not curb their behavior despite many neighbors asking them to. However, results suggest that, should a municipal bylaw prohibiting the feeding of deer be established, social (injunctive) norms may play an important role toward compliance.

Conversely, residents who were non-feeders tended toward ecologistic-scientific and utilitarian value positions. The non-feeders' expressed emotions of happiness in seeing deer. However, they all balanced these statements with additional emotions that expressed anger (frustration, concern, and worry) and sadness about seeing so many deer in their neighborhoods. An important emergent theme with residents who do not feed deer is cost. They expressed frustration over the unusually high congregation of deer in their neighborhoods and the costs they incur as a result of neighboring residents who attract deer with artificial food sources. These residents questioned status quo management, arguing they alone pay the price of expensive fencing and property management costs and suggested wildlife damage costs should be equally shared among all GWA residents.

This research suggests the importance for managers to investigate the social as well as ecological considerations behind human-wildlife conflict in order design strategies most successful at mitigating human-deer conflict as well as human-human conflict. Multi-species living within city spaces is complex and will require an inter-disciplinary approach with the exploration of creative ways to work toward responsible co-existence. Public education alone will not be sufficient in modifying resident behavior with respect to providing intentional food sources for deer. Mitigating for human-deer conflict within the GWA will require a combination of management approaches.

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CHAPTER FIVE

SPATIAL AND TEMPORAL ANALYSIS OF FACTORS ASSOCIATED WITH URBAN DEER VEHICLE COLLISONS

5.1 Abstract

Increasing white-tailed deer (WTD) populations in human developed and populated areas may lead to an increase in human-wildlife conflict such as deer-vehicle collisions (DVCs). DVCs represent a human-wildlife conflict of serious concern given that they may result, most notably, in significant risk to human safety, deer mortality, and costly vehicle damage. Although many communities have developed databases that track the frequency and location of DVCs, there is a need for analysis of the factors that affect DVC locations in urban areas. Further study on deer movement patterns across roads in urban areas is valuable to help reduce the occurrence of DVCs on existing roads and to assist planning of future urban road design and placement.

Using 2005-2009 DVC data provided by the Manitoba Public Insurance Corporation (MPIC), this research investigated whether DVCs are spatially autocorrelated and temporally random within the GWA, and examined the land cover variables that are associated with high risk DVC roadways located within urban space. Further, the research investigated whether social behavior, by way of providing artificial food sources for deer, may be influencing the location and occurrence of DVCs in metropolitan space.

This research showed that DVCs in urban areas are not spatially or temporally random, and that social behavior plays a role in the frequency and location of DVC occurrence in the GWA. The research found DVCs occurred more frequently near developed land and grasslands. The research identified factors that are associated with

DVCs in an urban area that provide opportunities for direct management strategies to be best applied to reduce DVC frequency.

5.2 Introduction

Vehicle accidents involving white-tailed deer (WTD) (*Odocoileus virginianus*) are occurring at an alarming rate throughout North America and are considered a serious problem (Romin & Bissonette 1996). DVCs may result in significant risk to human safety, deer mortality, and expensive vehicle damage (Finder et al. 1999). Conover et al. found that 92% of deer hit by a vehicle die (Conover et al. 1995). In the United States, estimates suggest that annually over 1 million drivers are involved in DVCs with more than 29,000 human injuries and 200 human fatalities (Conover et al. 1995) resulting in more than $1 billion in vehicle damage (Conover 1997). Similarly in Canada, approximately 60,000 Canadian drivers hit a deer each year, costing Canadian tax payers over $200 million annually (Transport Canada webpages: http://www.tc.gc.ca/eng/).

In the province of Manitoba, estimates suggest that nearly 300 people are injured annually, some seriously, in DVCs (Manitoba Public Insurance Corporation 2010). Today, MPIC spends over $30 million per year on automobile insurance claims involving wildlife, of which 6500-8500 of these collision claims involve WTD (Province of Manitoba webpages: http://www.gov.mb.ca/). The social costs associated with DVCs are also very high, considering, among other factors, human trauma, absence from work, and the costs associated with those employed to respond to such collisions (Hansen 1983).

5.2.1 Social Considerations of DVCs

The concept of social (cultural) carrying capacity is defined as the maximum wildlife population that a society will accept within a given area (Decker & Purdy 1988; Riley et al. 2002). Social carrying capacity is difficult to determine given that it is based on a variety of views of a large number of stakeholders and the threshold of acceptance is not static. Stakeholders' acceptance of tolerable wildlife population size, or of conflict levels, may vary. The benefits and liabilities wildlife populations present to various stakeholders differ (Conover 2002). Given these complexities, stakeholders often do not see eye-to-eye on the acceptable wildlife population size or on the course of management action that should be taken to alleviate conflicts (Decker et al. 2001).

Social carrying capacity (Decker & Purdy 1988) has been applied to study overabundant WTD populations (Decker & Gavin 1987). Studies have explored human perceptions and attitudes with respect to deer-related vehicle accidents (Marcoux & Riley 2010; Stout et al. 1993). A quantitative human dimensions study conducted within the GWA investigating resident opinions and tolerances toward the urban deer population identified DVCs as GWA residents' top deer-related concern (McCance 2009).

DVCs occurring in urban areas introduce new social considerations. Strong emotions may be experienced by urbanites who witness a deer struggling on the side of the road, downed but not killed by a vehicle collision. This can be traumatic, especially for urbanites, in many cases generations removed from living in close proximity to wildlife, who regard these animals as they would their domesticated pets (Adams et al. 2006; Louv 2008). Civic departments have to be equipped to respond quickly and handle the complexities of dispatching downed deer in a public forum. In other cases, deer that have been hit by a vehicle in an urban area, struggle onto residential property and die, leaving residents with decaying carcasses and its associated conflicts. Resident behavior may also influence deer movement onto and across roadways resulting in serious social conflicts between neighbors (see Chapter 4). Therefore, the social carrying capacity for DVCs in urban areas is suggestive, not simply of an individual's perceived fear of being involved in a DVC, but also of a myriad of other social considerations.

5.2.2 Management of DVCs

Numerous studies have investigated factors correlated with DVCs. The incidence of DVCs has been attributed to deer density (Widenmaier & Fahrig 2005; Sudharsan et al. 2006); season (Allen & McCullough 1976; Sudharsan et al. 2006; Ng et al. 2008); time of day (Marcoux et al. 2005); habitat type near roadways (Sage et al. 1983; Finder et al. 1999; Hussain et al. 2007); the number of buildings/degree of development near roadways (Neilsen et al. 2003; Hussain et al. 2007; McShea et al. 2008); traffic volume (McShea et al. 2008; Sudharsan et al. 2009); and roadway speed limits (Finder et al. 1999; Ng et al. 2008; Sudharsan et al. 2009).

Several management techniques have been suggested to mitigate, with varying success, the frequency of DVCs. Some of these techniques, aimed at reducing the occurrence of WTD on roadways, include deer population reduction (Brown et al. 2000; Riley et al. 2003); fencing (Puglisi et al. 1974; Falk et al. 1978; Feldamer et al. 1986; Putman 1997; Clevenger et al. 2001); under/over passes (Reed et al. 1975; Foster & Humphrey 1995; Rodriguez et al. 1996; Lehnert & Bissonette 1997; Putman 1997; Clevenger & Waltho 2000); intercept feeding (Wood & Wolfe 1998); whistles/repellents (Romin & Dalton 1992; D'Angelo et al. 2006); and reflectors (Schafer & Penland 1985; Romin & Dalton 1992; Vercautern et al. 2006). Other techniques have been aimed at improving a driver's ability to respond to deer on roadways. These include such techniques as reduced speed limits (Allen & McCullough 1976; Case 1978; Bashore et al. 1985); habitat modification (Putman 1997); improved lighting (Carbaugh et al.1975; Allen & McCullough 1976; Reed & Woodard 1981); and warning signs (Romin and Bissonette 1996; Sullivan et al. 2004). However, many efforts to reduce wildlife-vehicle collisions, such as fencing, have larger ecological implications, such as blocking migratory routes for numerous species and interrupting their access to key resources (Sullivan et al. 2004).

Within the GWA, a series of management techniques aimed at improving a drivers' ability to respond to deer have been adopted to mitigate DVCs. Warning signs, speed limit enforcement, and improved lighting have been used within the GWA.

5.2.3 DVCs in Urban Areas

In urbanized areas, DVCs are increasing at a disturbing rate (Squires 2002). The problem of DVCs in urban areas is a particular concern given high deer densities (Alverson et al. 1988) and high human population density with substantial levels of vehicle traffic (Squires 2002). The GWA, in accordance with many other metropolitan areas in North America, has experienced a substantial increase in the number of motor vehicle accidents involving WTD over the past three decades. The City of Winnipeg in 1976 reported 48 DVCs (Shoesmith & Koonz 1977), in comparison to the 464 DVCs reported in 2009 (Manitoba Public Insurance Corporation, Unpublished Data), nearly ten times the amount reported in 1976. Huijser et al. estimates the average DVC in Canada costs $6,600, suggesting that an excess of $3.2 million is spent annually on collisions in the City of Winnipeg alone (Huijser et al. 2009). Such figures record only the reported DVCs and it is believed that the true number of deer-vehicle encounters is actually much higher. Similarly disturbing statistics such as these are recorded for several urban areas in provinces across Canada. The need for direct management strategies to address DVCs is apparent and the cost-benefits of mitigation measures far exceed the costs associated with the status quo (Huijser et al. 2009).

5.3 Objectives

Previous research has shown that DVCs are not temporally or spatially random (Bashore et al. 1985; Finder et al. 1999). Although many communities have developed databases that track the frequency and location of DVCs, there has been little analysis of the factors that influence DVC locations in urban areas (Nielsen et al. 2003). Gaining more knowledge of the factors, both ecological and social, that influence deer movement onto and across roadways is needed to guide potential management strategies to mitigate DVCs on existing roads and for planning future road design and placement (Finder et al. 1999).

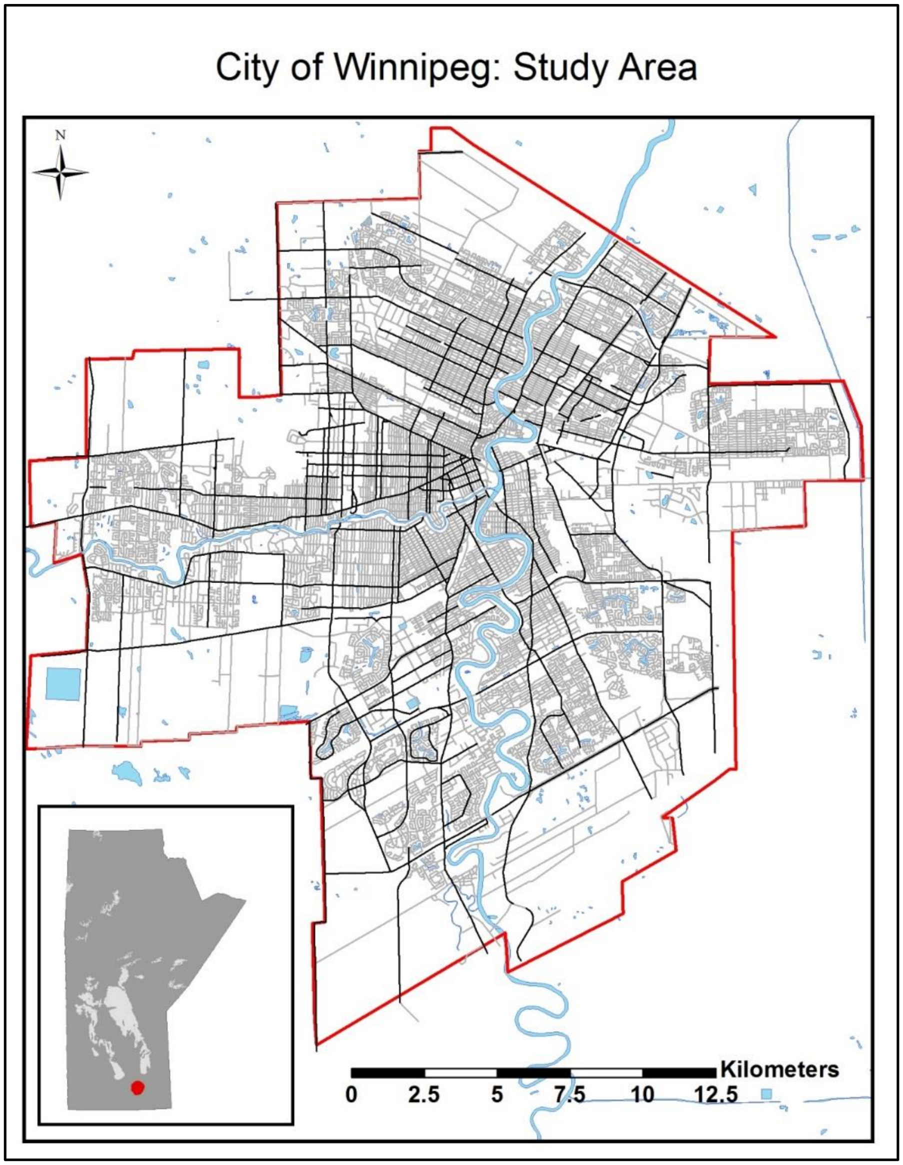
Building on this past research, and focusing on urban DVCs, this study determined the factors, both ecological and social, that contribute to the frequency of DVCs within the GWA. The research further explored the temporal occurrences of urban DVCs by month, day of the week, and time of day in which they occur. The study also investigated whether DVCs were spatially autocorrelated within the GWA and examined the Land Cover Classification variables associated with high-risk DVC roadways located within city space. In combination with these analyses, the study examined the relationship between DVCs and urban deer density. Finally, the study investigated whether a positive correlation exists between deer movement, DVC occurrence, and intentional residential artificial feed sites. Analysis of the factors associated with DVCs may identify opportunities where direct management strategies can be best applied to reduce DVC frequency.

5.4 Methods

Wildlife scientists use innovative technology (e.g. GIS, remote sensing, and multivariate statistics) to research landscape influences such as vegetation, land use, topography, and traffic patterns on DVCs over large scale and urban landscapes (Nielsen et al. 2003).

5.4.1 Study Area

The GWA is located near the longitudinal center of North America, approximately 100km (62 mi) north of the border with the United States and 70 km (43 mi) south of Lake Winnipeg (Government of Manitoba webpages: http://www.gov.mb.ca/). The city spans approximately 464.01 km^2 with an elevation of 786 feet. Winnipeg is located in the Red River Valley, and is characterized by rich deep soils, flat topography, and a native tall grass prairie ecosystem (Scott 2007). The city has a humid continental climate (Koppen climate classification), with summers typically humid and hot, seeing temperatures rise to 35 C, and winters typically dry and cold, with temperatures falling to -35 C (Environment Canada webpages: http://climate.weather.gc.ca). The human population of the City of Winnipeg is 730,018 people (Canada 2011 Census). Map 5.1 illustrates the GWA study area used for this research as defined by MPIC.



Map 5.1: GWA Study Area

WTD have been an integral part of the GWA landscape for over 100 years (Goulden 1981). Historically, WTD were observed in small numbers in wooded areas along the Assiniboine and Red Rivers and the Charleswood area of the city up until the mid-1970s, with a population estimate of 200 deer at that time (Shoesmith & Koonz

1977). Since the late 1970s, however, the WTD population has been increasing: an aerial survey in 2006 recorded over 1,700 deer within the city and its near surrounding area (Hagglund 2006). Figure 5.1 provides a graphical representation of the estimated WTD population growth in the City of Winnipeg between 1970 and 2007 with projected potential population growth through until 2020.

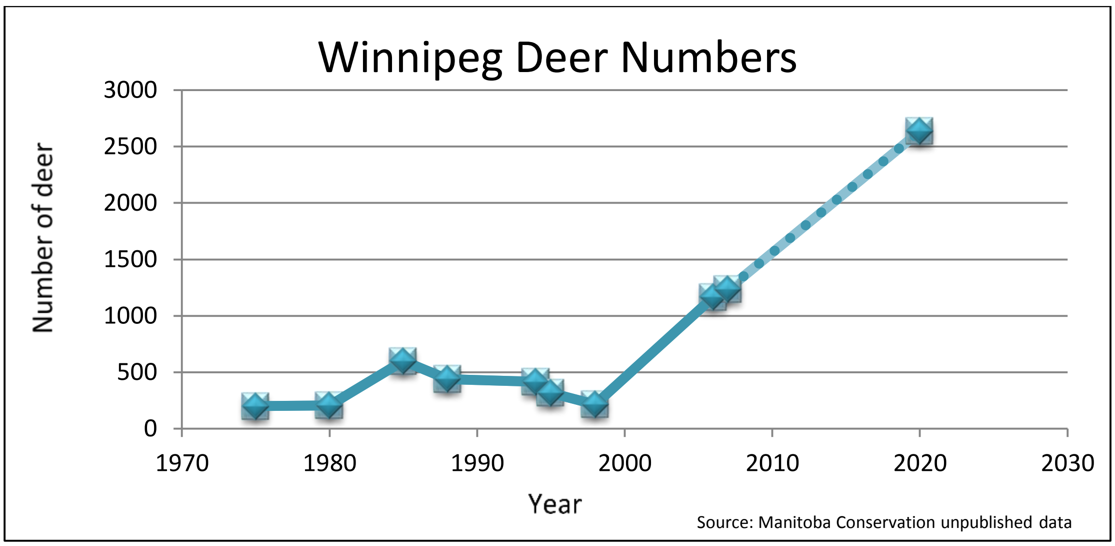


Figure 5.1: Estimated WTD Population Growth within the City of Winnipeg

5.4.2 Analysis and Global Information Systems

Using the DVC database provided by MPIC, the reported DVCs for the GWA from 2005-2009 were geo-located using ArcGIS 9.3. There were 324, 392, 403, 380, and 464 DVCs annually reported between 2005-2009 respectively, for a total of 1,963. These DVCs were those that were reported to MPIC, including their latitude and longitude, within the GWA for each year and stored in their in-house database.

5.4.3 *Temporal Analysis*

The study investigated the temporal occurrence of DVCs within the GWA. The 1,963 DVCs reported within the GWA from 2005-2009 were separated by month, day of week, and hour of the day in which they occurred. Chi-square testing was used to determine whether DVCs occurred more frequently during certain months, days, and times.

5.4.4 *Spatial Analysis*

5.4.4.1 Spatial Autocorrelation of DVCs

To explore the relationship of the DVCs with respect to each other (spatial autocorrelation), an average nearest neighbor calculation on the 2005-2009 DVC data was conducted. Using 2,500 x 2,500 meter grid blocks, Moran's I, a cross-product statistic was carried out to determine whether DVCs were spatially autocorrelated. Dale et al. defines spatial autocorrelation as the degree to which a set of features tend to be clustered together (positive spatial autocorrelation) or to be evenly dispersed (negative spatial autocorrelation) (Dale et al. 2002). Spatial autocorrelation can be measured using Moran's I.

The 2,500 x 2,500 meter grid blocks were used as a means of creating uniform cells of measurement overlaid over the total area of the GWA. This unit of measurement was determined most effective given the size of the overall area and the location of roadways. Often, roadways are used as jurisdictional boundaries which was ineffective to use in this analysis.

5.4.4.2 DVCs in relation to Land Cover Classification Types

In order to investigate whether DVCs occurred more frequently near certain land cover types a spatial join was conducted in ArcGIS 9.3 between the 2005-2009 DVC locations and the Canadian Land Cover Classification (LCC) layer. A spatial join affixes the attributes of two feature classes (the DVC locations and the LCC land cover types) based on the spatial relationships between the features to assess the LCC land cover types that are associated with higher DVC occurrences (ESRI webpages: www.esri.com).

The LCC is a national land cover spatial database developed by the Canadian Federal government with data integrated from the major federal departments involved in land management in Canada, such as Agriculture and Agri-Foods Canada (AAFC), Canadian Forestry Service (CFS), and the Canadian Center for Remote Sensing (CCRS). Using the LCC, the land cover classification type found in closest proximity to the DVCs is determined.

The same methods of analysis were repeated using 10,000 random points along GWA roadways to determine whether the summary results from the DVC data were independent of what would be observed if the distribution of values were random. In order to assess similarities and differences between random points and Global Positioning System (GPS) data, often five times the number of GPS data points is generated as random points for comparative analysis (Johnson & Gillingham 2005).

5.4.4.3 Spatial Autocorrelation of GWA Deer Population

In order to explore the relationship of deer count observations (Hagglund 2006), Moran's I was conducted on the deer count observation layer (based on the 2006 aerial survey conducted by Manitoba Conservation and Water Stewardship (MCWS)). Figure 5.2 illustrates the number and location of deer as identified during the 2006 aerial survey.

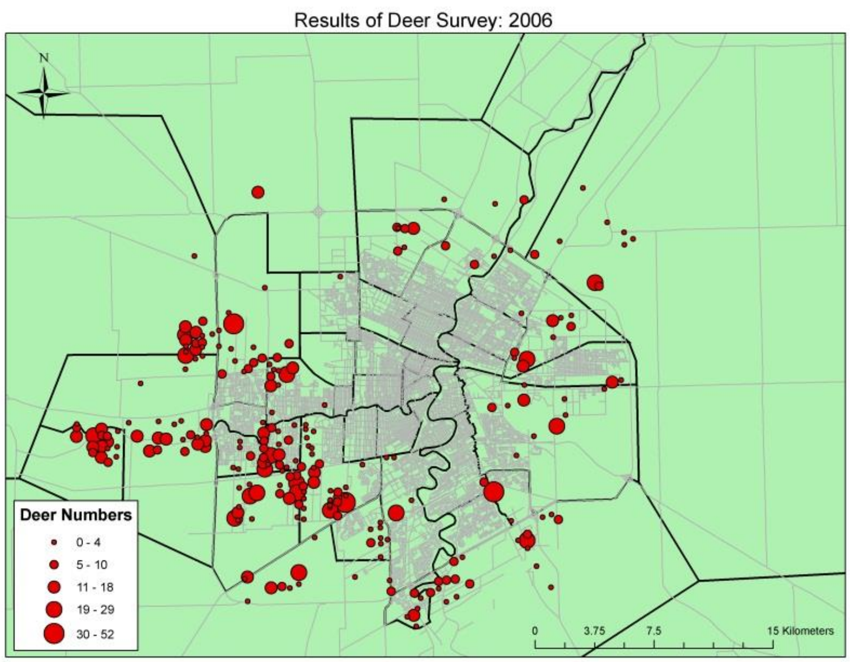


Figure 5.2: The Number and Location of WD Identified in the GWA during an Aerial Survey Conducted in 2006

5.4.4.4 Geographic Weighted Regression

In order to assess whether there is a correlation between higher deer count observations and higher occurrences of DVCs, a geographic spatial regression analysis was conducted to investigate the relationship between DVCs and deer observations using 2,500 x 2,500 meter grid blocks.

5.4.4.5 GWA Deer Movement Data

As a part of a larger research initiative, GWA WTD were collared with Wild Cell GSM collars in March 2010 until January 2013 (n=18) using Clover Box Traps. GPS fix locations were taken every two hours. This research received Animal Ethics Approval from the University of Manitoba, Protocol number F09-034 (Appendix A). Deer movement data between March 10, 2010 and March 31, 2011 was mapped using ArcGIS 9.3. Deer home range size was determined using Hawth's tools by calculating the Minimum Convex Polygon (MCP) for each animal.

Spatial analysis of deer movement indicated that collared urban deer were spending a considerable amount of time visiting a select few residential properties. To investigate this further, deer movement from the GWA deer that were collared for a minimum period of six months was mapped and analyzed using ArcGIS 9.3. A spatial join was conducted between the GWA collared WTD movement data and the LCC to determine collared urban deer movement in relation to land cover types. Results indicated that the urban collared deer were spending a considerable amount of time on developed properties. Further investigation into the deer path movements, using the 'Create attributed lines from points' tool in ArcGIS 9.3 (Buja 2009), found deer were visiting a select few residential properties multiple times a day. The residential properties showing the greatest density of deer location points/square meter for the first six months that the deer were collared were isolated. This analysis used the first six months of the animal's movement given this offered enough time for the deer to settle down after the stress of capture and collaring activities while also allowing for animal movement to be assessed over winter and spring months.

To explore further why a select number of residential properties were visited often, the registered owner of the residential property showing the greatest density of deer location points/square meter for each collared deer (as determined through the above methodology), was approached and asked to participate in a one-on-one personal interview (n = 14). The personal interviews (n = 11) used a critical case study approach, were semi-structured, and adopted a directive style (Denzin & Lincoln 2003). This research received approval from the Joint-Faculty Research Ethics Board at the University of Manitoba, Protocol number J2009:116 (Appendix D). Data gathered from these interviews were transcribed and analyzed (see Chapter 4).

Using the Home Range Extension Function in ArcGIS 9.3 (Rodgers et al. 2007), the high density core use areas for the deer were mapped in relation to the confirmed cases of DVCs and the confirmed cases of artificial food sources as identified through personal, one-on-one interviews to assess the locational correlation between deer movement, DVCs, and artificial food sites.

5.5 Results

5.5.1 Temporal Analysis

The temporal occurrence of the 1963 DVCs occurring within the GWA from 2005-2009 was investigated. Figure 5.3 represent the number of DVCs occurring within 2005-2009 in the GWA by the month in which they occurred.

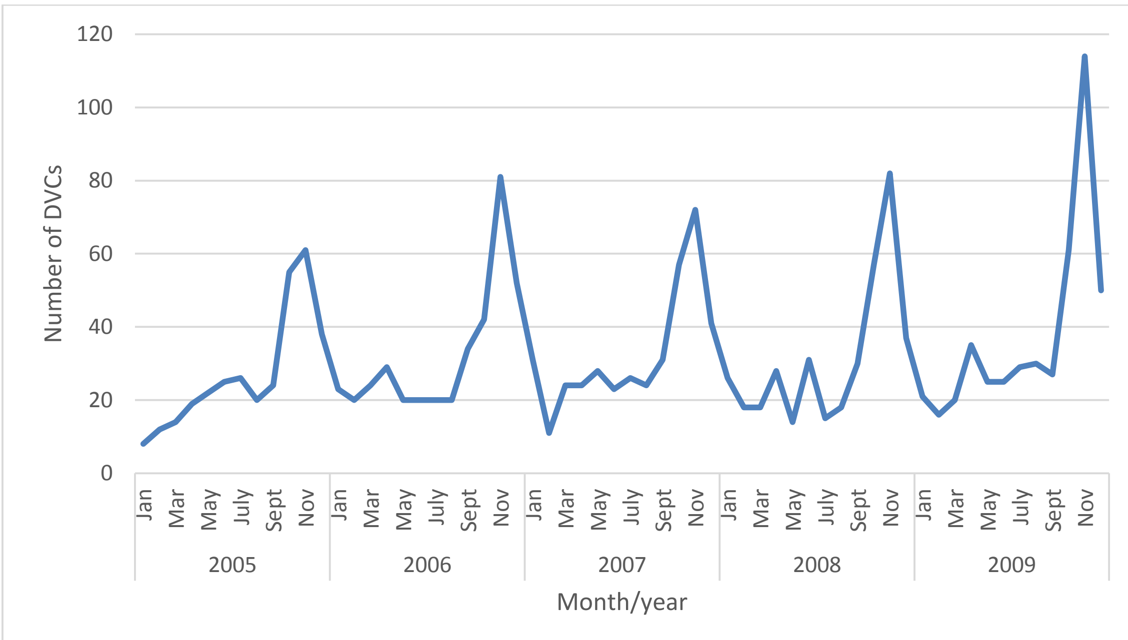


Figure 5.3: Graphical Representation of the Monthly Occurrence of DVCs from 2005-2009 within the GWA

Using the 1963 DVCs within the GWA from 2005-2009, the DVC occurrences during each day of the week were investigated. Table 5.1 represents the number of DVCs occurring within the GWA from 2005-2009 by the day of the week in which they occurred.

Table 5.1: Daily Occurrence of DVCs from 2005-2009 within the GWA

	Sunday	Monday	Tuesday	Wed.	Thurs.	Friday	Saturday	Total
2005	37	41	53	53	44	54	42	324
2006	39	54	52	68	60	54	65	392
2007	51	64	45	57	69	55	62	403
2008	52	60	45	48	73	55	47	380
2009	46	82	78	68	59	79	52	464
Total Percent	**225 (11.5%)**	**301 (15.3 %)**	**273 (13.9%)**	**294 (15.0%)**	**305 (15.5%)**	**297 (15.1%)**	**268 (13.7%)**	**1963 (100%)**

An investigation of the time of day in which the 2005-2009 DVCs occurred was also conducted. Figure 5.4 represents the number of DVCs occurring within the GWA from 2005-2009 by the time of day in which they occurred.

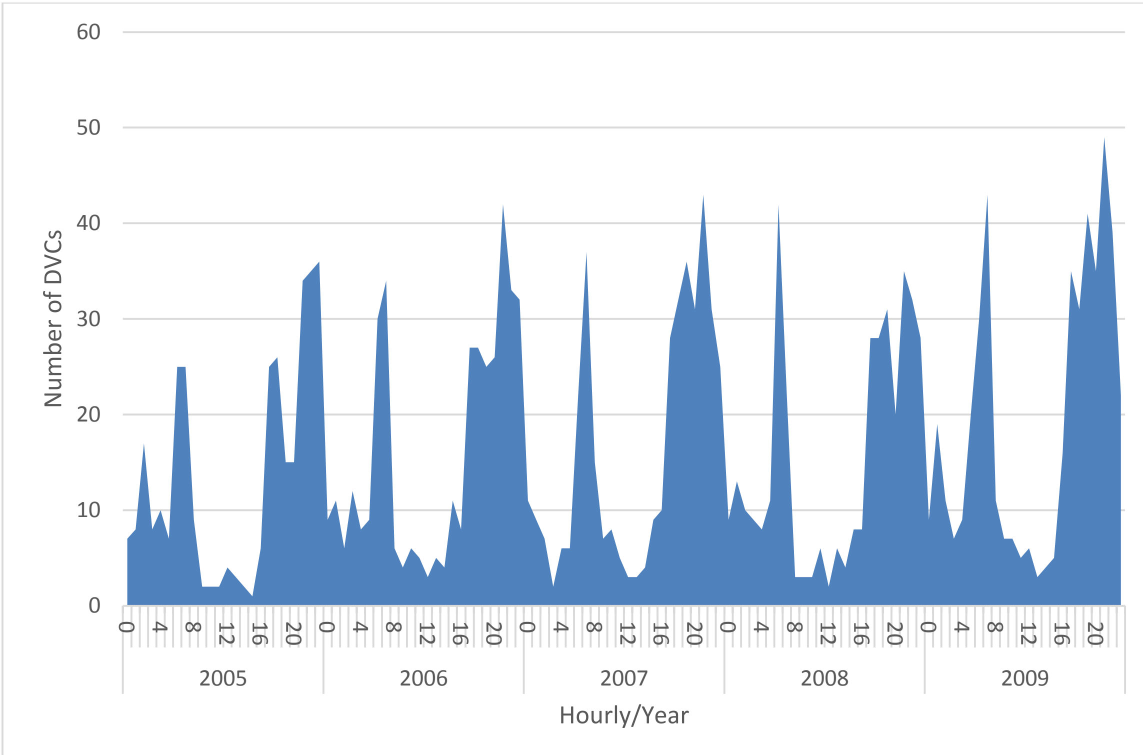


Figure 5.4: Graphical Representation of Time of Day the 2005-2009 DVCs Occurred within the GWA

Chi-squared testing (alpha 0.05) was conducted to determine whether the difference in occurrence of DVCs during 5 am-9 am and 5 pm-10 pm was significant. The hours of the day were separated into those that fell within dusk and dawn hour blocks (any hours between 5 am-9 am and 5 pm-10 pm) with those that did not. These hours were selected based on the sunrise and sunset times for the GWA (World Clock webpages: www.timeanddate.com/worldclock). Using the combined total DVCs/hr for all data from 2005-2009 (1963 collisions), the hours of DVCs defined as high risk (100 or more DVC/hr) were separated from those defined as low risk (99.9 or less DVC/hr). The results of the chi-squared tests show dusk and dawn as high risk times for DVCs as statistically significant.

5.5.2 *Spatial Analysis*

5.5.2.1 Spatial Autocorrelation of DVCs

Based on average nearest neighbor test scores, DVCs were clustered and not randomly dispersed with a Z score of -57.54, observed mean distance/expected mean distance of 0.28, and a significance level of 0.01. Given the average nearest neighbor index (average nearest neighbor ratio) is less than 1, the pattern exhibits clustering. Similarly, using the 2,500 x 2,500 meter grid block approach, DVCs were clustered, with a Moran's I index of 0.47, Z score of 8.14, and significance level of 0.01. A Moran's I index value near +1 indicates positive autocorrelation (clustered relationship) and near -1 indicates dispersion. Given the results reflect a very high Z score of 8.14 (much higher than 2.58) and a very small p-value of 0.01, it is unlikely that the observed spatial pattern reflects a theoretical random pattern.

5.5.2.2 DVCs in Relation to Land Cover Types

The relationship between DVCs and nearest land cover type is shown in Table 5.2.

Table 5.2: GWA DVCs in Relation to Nearest Land Cover Type between 2005-2009

LCC	Year					Grand Total
	2005	2006	2007	2008	2009	
Annual Crops	12	3				15
BroadLeaf Dense	6	5	4	5	2	22
Cultivated Agricultural Land	22	21	17	11	16	87
Developed	207	270	260	224	316	1,277
Exposed Land		2	1	1	2	6
Grassland	69	90	121	139	128	547
Herb	3					3
Water	1	1				2
Other	4					4
Total	**324**	**392**	**403**	**380**	**464**	**1,963**

This summation highlights that 93% of the 2005-2009 DVCs occur near developed or grassland cover types.

5.5.2.3 10,000 Random Points

Table 5.3 provides the summary of the spatial join and illustrates the random points in closest proximity to the LCC types.

Table 5.3: Random Point Allocation in relation to the Nearest LCC Type

LCC	Count
Annual Crops	193
BroadLeaf Dense	309
Cloud	2
Cultivated Agricultural Land	1,789
Developed	5,146
Exposed Land	36
Grassland	2,224
Herb	58
MixedWood Dense	1
Water	242
Total	**10,000**

The LCC layer and the random points comparison indicated that the three habitat types in closest proximity to the random points were developed land (51.46%), grasslands (22.24%), and cultivated agricultural land (17.89%).

Chi-squared testing confirmed there was a statistically significant difference between DVC proximity to the various LCC types compared to the random points.

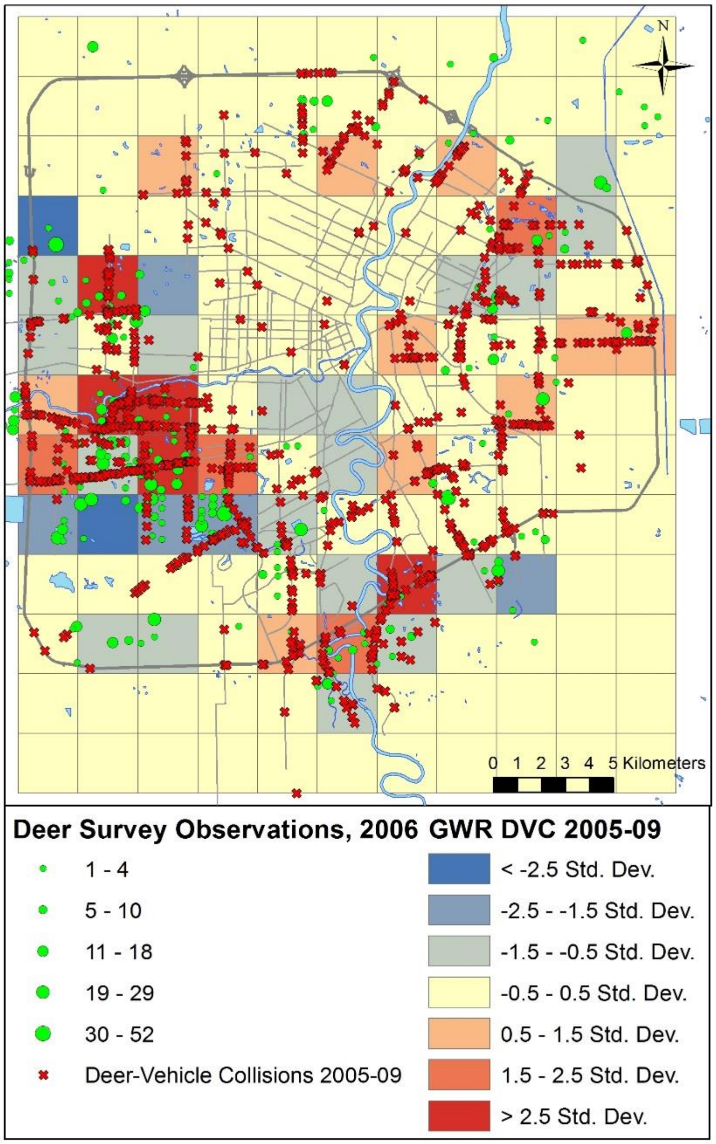
Results support that DVCs have a higher probability of occurring near developed land and grassland land cover types.

5.5.2.4 Spatial Autocorrelation of 2006 Deer Survey Results

Using the 2006 deer survey results, a Moran's I test was run to determine whether the deer locations were spatially autocorrelated within the GWA. The location of WTD within the GWA were clustered at the time they were identified during the 2006 deer survey with a Moran's I index of 0.11, a Z score of 5.37, and a significance level of 0.01.

5.5.2.5 Geographically Weighted Regression

A geographically weighted regression was performed based on 2,500 x 2,500 meter grid blocks within the GWA to assess the correlation between DVCs and deer observations within each grid block (Map 5.2).



Map 5.2: Deer survey grid block areas within the GWA illustrating the correlation between DVCs and deer observations within each block for 2006

Given that standard deviation is a measure of the spread or dispersion of a set of data (Mitchell 2002). The geographic weighted regression builds a local regression equation for each feature in the dataset. The darker shaded areas illustrate the degree of correlation of DVCs to the deer observations with a spread between the data sets falling within 95% or 99% of the value limits. Very high (+2.5) or low (-2.5) indicate a 99% confidence level that the P-value is 0.05. An associate of +1.96 or -1.96 indicate a 95% confidence level that the P-value is 0.05. Therefore, based on the regression results shown here, the high deer density grid blocks are highly correlated to grid blocks representing higher occurrences of DVCs.

5.5.2.6 GWA Deer Movement Data in Relation to LCC

The results of the spatial join between the collared deer data to the nearest land cover type is shown in Table 5.4.

Table 5.4: GWA GPS Collared Deer Movement Data in relation to the LCC Type

LCC	Fall	Spring	Summer	Winter	Grand Total
Annual Crops	249	449	169	133	1,000
BroadLeaf Dense	3,410	5,803	3,898	5,651	18,762
Cultivated Agricultural Land	944	1,251	2,936	254	5,385
Developed	3,476	2,171	2,110	4,562	12,319
Exposed Land	230	131	157	250	768
Grassland	6,768	4,867	4,069	7,287	22,991
Herb	148	252	150	272	822
MixedWood Dense	44	3	7	134	188

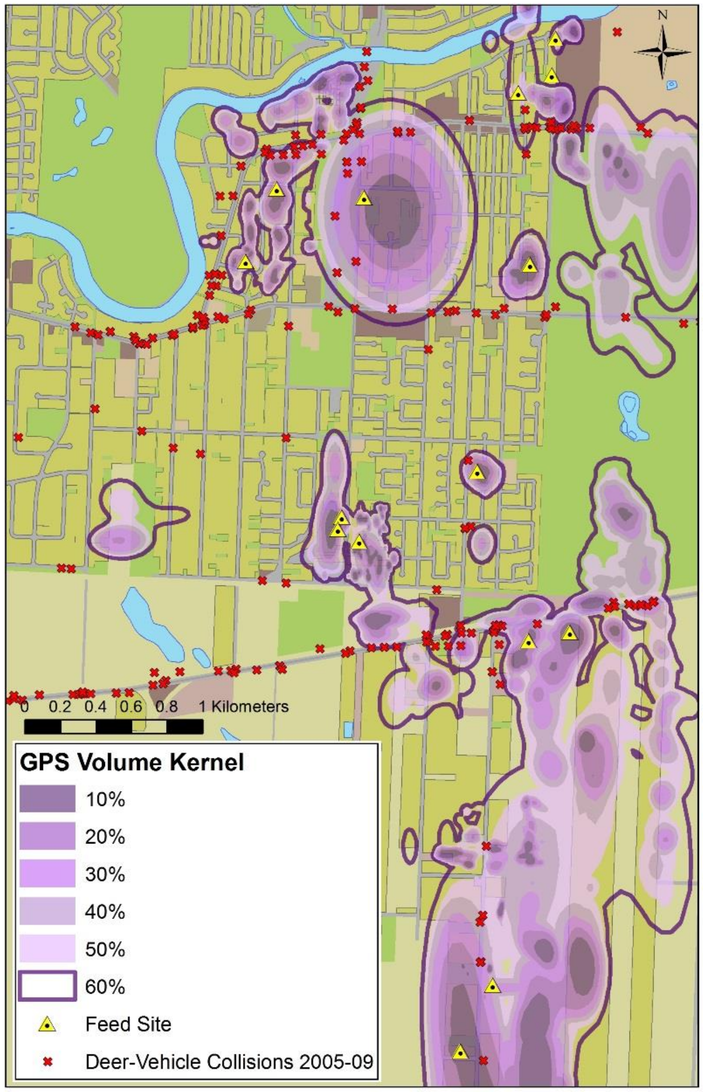
Water	91	68	79	157	395
Total	**15,360**	**14,995**	**13,575**	**18,700**	**62,630**

5.5.2.7 GWA Deer Movement Data

GWA deer spent considerable time frequenting developed landscapes and grasslands found on vacant tracts of public property behind residential housing within the GWA (see Table 5.4). As a part of a larger research objective, the 'Create attributed lines from points' tool in ArcGIS 9.3 indicated that deer are visiting a select number of residential properties multiple times a day, traveling across busy roadways as they move from protective cover (broadleaf) to visit these select few residential properties. Based on these findings, personal one-on-one interviews were conducted with these select residential property owners. Results of the personal interviews suggested that all (100%) of these selected residential properties, where deer showed the highest number of location points, were associated with an intentionally supplied artificial food source (see Chapter 4).

Using the Home Range Extension Function in ArcGIS 9.3 (Rodgers et al. 2007), the high deer density core use areas deer were mapped in relation to the confirmed cases of artificial food sources as identified through qualitative interviews. Map 5.3 shows the correlation between the deer location points, confirmed intentionally supplied artificial food sources, and the occurrences of DVCs. The map illustrates the known intentionally supplied artificial food sources are located within the high deer density core use areas.

The DVCs occurrence roadways are those found within, or directly adjacent to these high deer density core use areas.



Map 5.3: GPS collared deer density cores in relation to DVCs and artificial food sites

5.6 Discussion

5.6.1 Temporal Analysis

November, October, and December were the three months of the year with the highest occurrence of GWA DVCs respectively. This timeline is consistent with the months of the year that deer are actively breeding in the GWA (Goulden 1981). During fall, males are travelling farther to find females in estrus and males looking to breed may "push" females (Beier & McCullough 1990). This increase in DVCs is consistent with the months of the year when males are moving the longest distances (Chapter 2). This time is also when deer are actively building up food stores in preparation for winter and therefore moving to find high protein food sources ((Hesselton and Hesselton 1982), likely increasing the risk of DVCs. This time of year also represents the seasonal variation associated with changing duration of daylight hours. These months are characterized by shorter days with earlier sunsets and an increased number of hours of reduced visibility. Similar findings in regard to DVC occurrences during the fall months were documented by Hubbard et al. 2000 who found the highest number of DVCs in Iowa occurred in May and November, and Ng et al. 2008, who found that DVCs in Edmonton, Alberta peaked in mid-November.

There were slightly fewer DVC occurrences on Sunday; however, overall, there was little variation in the number of DVC occurrences during day of the week.

The temporal analysis of the DVC occurrence relative to the hour of the day indicated a higher occurrence of DVCs during dawn and dusk. This is not surprising given deer behavior and research suggesting that white-tails are most active during dawn and dusk (Beier & McCullough 1990). Further, more DVCs occurred during the evening after 8pm than during the day after 8am. This can be explained because deer may be bedding down chewing their cud during the day and more actively moving and feeding during the night (Goulden 1981). These results are consistent with the U.S. Department of Transportation Report (August 2007), which identified, on America's highways, a higher number of DVCs after 5pm until midnight and another peak found between 5am and 8am (Huijser et al. 2007). These results illustrate that DVCs are not temporally random, but rather occur more frequently at dusk and dawn, findings which are consistent with the earlier works of Bashore et al. 1985; Hubbard et al. 2000; and Nielsen et al. 2003.

5.6.2 Spatial Analysis

DVCs were not spatially random. The average nearest neighbor and confirmed by the Moran's I test on the 2005-2009 DVCs illustrated that the DVCs are clustered within the GWA. These results are consistent with the research conducted by Nielsen et al. (2003) and Gonser et al. (2009) that also found DVCs are not randomly located.

Results of the analysis of DVCs in relation to the LCC highlight that 93% of the occurred near developed or grasslands land cover types, found behind residential homes within the GWA. These results are consistent with the research findings of Sudharsan et al., who suggest a higher probability of DVCs occur near heavily human populated and agricultural areas (Sudharsan et al. 2009). Similar to the findings of the State of Washington's analysis of DVCs, this analysis indicated that grasslands are associated with higher numbers of DVCs. However, research in the State of Washington study found both grasslands and wooded areas to be associated with increased DVCs. Their study attributed this result to the fact that both cover types are important for deer forage (Myers et al. 2008). Similarly other researchers have found a higher occurrence of DVCs near woodlots (Finder et al. 1999; Hussain et al. 2007). However, in this study, increased numbers of DVCs were more associated with developed land cover than woodlots, suggesting perhaps that the GWA urban deer life needs and food requirements are being met readily within developed landscapes in the GWA.

The GWA deer population was not spatially random but rather clustered within urban space. The geographically weighted regression illustrated a high degree of correlation between high deer density and DVC occurrence.

Building on the above findings, spatial analysis of the collared deer movement in combination with personal interviews confirmed a positive correlation between deer density, movement, and artificial feed sites. Given the determination that high deer density and DVCs are highly correlated and further that deer density is heavily influenced by artificial feed sites, this research exposes the connectivity between the human social behavior of intentionally supplying artificial food sources for deer and the occurrence of DVCs within the GWA. Sudharsan et al. (2009) also found connectivity between high

DVC roadways and landscape types where deer access a food source; however, in their research, these collisions were associated with agricultural crops.

Overall, the results of this study suggest that urban DVCs are positively correlated to deer density, certain land cover types, and occur more frequently during certain times of the day and months of the year. These results are consistent with other research that has been conducted. However, this research also suggests that human behavior may play a significant role in influencing the occurrence of DVCs in urban areas. Artificially supplied food sources may result in smaller WTD home range sizes, and cause urban WTD to reside in close proximity to an artificial food source and therefore, within a matrix of busy city streets (Chapter 2). Results identify a positive correlation between the artificial food source, deer GPS location points, and DVC occurrence. Therefore, the human social behavior of providing artificial food sources to urban deer (Chapter 4) may be influencing DVC location and frequency of occurrence in the GWA.

5.7 Management Implications

These study findings are useful for managers and civic agencies assigned the task of creating management plans aimed at reducing GWA urban DVCs. The finding suggest overall that localized management of DVCs may be most effective. Given the degree of complexity and the inter-related factors inherent within urban spaces, it is difficult to directly relate the frequency and location of DVCs to the human behavior of supplying an artificial food source; however, study findings do expose a correlation between an artificial food source, deer core use areas, and DVC locations. Strategies aimed at reducing the availability of intentionally supplied artificial food sources within the city may be useful. Management strategies should be specifically designed during the times of day and year when a higher number of DVCs occur. Localized management near key habitat types that are associated with higher numbers of DVCs should be considered and could include management actions such as vehicle speed control zones, improved lighting, and improved warning systems.

5.8 Conclusions

The GWA urban DVCs are not spatially or temporally random. The GWA DVCs occur most often in high deer density neighborhoods, at dusk and dawn. GWA DVCs occur most often during fall months (November, October, and December) near developed land and grassland cover types. Social factors, such as urban residents intentionally providing artificial food sources influences the occurrence of DVCs in urban space. The factors that influence urban DVCs identified by this research provide opportunity for managers to predict high risk DVC roadways, mitigate DVCs through specified management, and effectively plan for urban spaces and roadways that consider DVC occurrence. Effective management strategies adopted to address high risk DVC roadways will need to be multifaceted. Results of this research suggest that GWA management may want to consider incorporating municipal bylaws prohibiting deer feeding and enforcement of fines for non-compliance, in combination with public education to help reduce the number of residents intentionally supplying artificial food sources for deer and thereby potentially mitigating the occurrence of urban DVC incidences.

5.9 Works Cited

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CHAPTER SIX

CONCLUSIONS AND CONTRIBUTIONS TO NEW KNOWLEDGE

6.1 Research Contributions

The research documented in this collection of manuscripts offers several contributions to existing methodological and empirical knowledge, as well as makes a contribution to the accumulation of new knowledge in several areas. Several studies have assessed deer movement but few have done so in urban environments through the use of Global Positioning System (GPS) technology, in combination with an investigation of the influence of human social behavior on deer movement. Residents' behaviors, tolerances, value orientations, and emotions vary substantially. Specific human behaviors can result in localized high densities of urban deer. The findings derived from this integrated research project expose the role of human social behavior in defining the frequency and nature of human-wildlife interaction, inevitably connected to human-wildlife and human-human conflict in urban areas.

Overall, the research presented herein is based on the premise that urban spaces should be designed in ways that incorporate natural spaces and support species co-existence. This notion is based on the concept of the "zoopolis" (Wolch 1998), a necessary transformation of largely de-natured metropolitan spaces into innovative urban environments supporting biodiversity and human connectivity with nature (Louv 2008). Based on this premise, the research suggests that management within city landscapes should aim to support the presence of both people and deer. I formulated this premise based on the awareness that urban sprawl continues to radically modify the global footprint and to alter landscape heterogeneity. Landscape heterogeneity, although imperative to ecosystem function and the survival of populations and communities of species, continues, as a result of urbanization, to decline.

This research is also founded on the notion that wildlife management objectives and actions must consider knowledge and perspectives across multiple disciplines, suggesting that, in order to understand urban deer movement, management research and policy must necessarily be inter-disciplinary and at minimum, draw from knowledge on deer ecology (GPS supported deer movement data, habitat selection, seasonal movement patterns) in combination with knowledge of human community social dynamics (social behavior, wildlife value orientations, and discrete emotions). Moreover, the present research was guided by the notion that each human community functions differently, and that human perspectives and emotions are embedded in the historical and cultural frameworks of a given community. Therefore, critical to wildlife management within these urban communities is the need to gain a better understanding of the human-animal relations that shape present societies. The imperative need for spaces designed for the co-existence of species, in combination with urban residents' expectations for wildlife, is suggestive of the necessity of integrating human-dimensions into biological and ecological wildlife research (Leong 2007). In this respect, two–way communications (Gore 2007) become imperative for urban deer movement studies: communication between researcher and collar hardware, but also equally as important, between researcher and the broader public. My research findings support the assumption that human social behavior influences urban deer movement. The present research offers a conceptual framework for future studies aimed at assessing the interactions between wildlife and the broader human community.

As a third point, this research is based on the hypothesis that urban and rural systems differ in significant ways and therefore that the ecology and behavior of deer residing in urban and rural landscapes may well vary. Research outcomes validate this hypothesis, exposing statistically significant differences between urban and rural deer movement patterns, home range sizes, habitat use, including variations in the length and rate of their seasonal and monthly movements.

Lastly, this research is based on the assumption that human-wildlife conflict (represented by DVCs) is associated with deer ecology and behavior, as well as human social dynamics, and therefore that understanding of both of these aspects is necessary for conflict management, and ultimately, for successful urban species co-existence. Results of this study indicate that human behavior determines the frequency and location of human-wildlife conflict, a datum that offers insights into management strategies that might best be designed to mitigate conflict within the realm of the complex dynamics characteristic of urban spaces.

6.1.1 Methodological Contributions

The research described within this dissertation adopted several methodological approaches that add to the existing literature and offer an opportunity for future research studies. This research used animal-borne GPS-supported data to assess the home range sizes, seasonal movement patterns, and habitat use of urban WTD. GPS technology has been studied extensively to assess the overall effectiveness of the technology for animal movement research studies (Rodgers et al. 1996; Coulombe et al. 2006). GPS collars offer the capacity to collect multiple daily fixes (day or night) over extended time periods, deriving unbiased and accurate data that can be used to investigate animal ecology in unprecedented ways (Rempel et al. 1995; Rempel & Rodgers 1997). Methodologically, within the context of this research, the GPS-supported deer movement data were integrated with the data derived from human dimensions research, specifically, information regarding social behavior, to offer a broader knowledge base as to how these two variables inter-relate. In order to enhance our understanding of the differences in deer movement within urban and rural systems, and the role human behavior plays in influencing deer movement, a comparative analysis of deer movement patterns within urban and rural environments was deemed necessary.

Building on this methodological framework in Chapter 3, the study utilized spatial analysis of the GPS-supported movement data, so the deer themselves "select" the critical case – the urban human resident - to be involved in the social dynamics analysis (Taylor 1998). The animal movement, therefore, identified the urban residents to be engaged and asked to participate in a one-on-one personal interview. These critical cases were studied in depth to investigate human behavior, wildlife value orientations, and discrete emotions. The data derived through these investigations were laid out on a "horizontal" plane (Taylor 1990) and analyzed through content analysis using a scan, order, review, and comparative methodology. This conceptual framework adopted a mixed-methods research design and offers a new methodological approach to the existing literature.

In Chapter 4, human-wildlife conflict (DVCs) was studied by integrating knowledge derived from DVC occurrence records, urban deer ecology and movement data, and human dimensions data, to create a robust framework that offers an enhanced broad spectrum understanding of the factors that influence human-wildlife conflict in urban areas. This combined approach offered greater clarity with respect to potential effective mitigation measures that may be adopted to manage human-deer conflict, specifically DVCs, in urban areas.

Further, this study offered a description of methodological approaches that can be employed when collaring, capturing, and handling WTD residing in urban landscapes, including cage trap specifications, recommendations for collar design and technology, and critical considerations for a safe and effective urban deer collaring program. These methodologies augment existing literature, offering modifications specific to larger deer and/or deer residing in northern latitudes.

6.1.2 Empirical Contributions

Recognizably, urban and rural ecosystems differ, calling for variations in wildlife management objectives and strategies with respect to species residing in urban versus rural landscapes. Findings derived from this research exposed several differences inherent within urban and rural ecosystems. Study results offered quantitative insights into differences between urban and rural WTD mortality, seasonal and monthly sex-specific home range size differences, habitat use differences, as well as differences in the length and rate of movements within various habitat types. Study findings also enhanced existing knowledge of urban and rural WTD migration movements and the influence of temperature and precipitation on urban and rural deer seasonal movement.

This study further exposed the role of human behavior in influencing urban deer movement patterns. Results derived from the critical case study offered an enhanced understanding of the value orientations and discrete emotions of urban residents engaged in the behavior of feeding deer and therefore attracting WTD to their property. Through these investigations, new value orientations emerged, beyond those of Kellert (1996), adding new knowledge to the existing literature. New value orientations ownership/possession and connectivity/self-belonging were identified and offer opportunities for their further exploration in future research.

Moreover, the research contributes to the existing literature with respect to the temporal and spatial occurrence of DVCs and the factors associated with their frequency and location of occurrence. Research findings supported the conclusion that urban DVCs are clustered and not temporally random. Research outcomes augmented existing research with respect to the time of day, time of year, and habitat types associated with the occurrence of DVCs within urban spaces. Additionally, the research added to this existing collection of work by exposing the connectivity between social behavior and DVC occurrence within the GWA.

Finally, lessons learned during a multiple-year urban deer collaring program shed light on unique considerations necessary for wildlife managers working in urban environments. Empirical information on trap specifications is offered, particularly given that lighter weight Clover box traps were found to be less effective for physical immobilization. This research provided information on a heavier modification to the Clover box trap than is readily recommended in the existing literature for larger deer, especially those found in northern latitudes. Urban wildlife research conducted within residential space requires distinct considerations of the diverse human perspectives and attitudes, as well as unique safety considerations associated with urban deer capture, handling, and collaring.

6.2 Urban-deer Dynamics Model

The following schematic model (Figure 6.1) represents a synthesis of knowledge acquired throughout the course of this research, specifically on the inter-related connectivity between the social, ecological, and biological disciplines imbedded within urban deer management

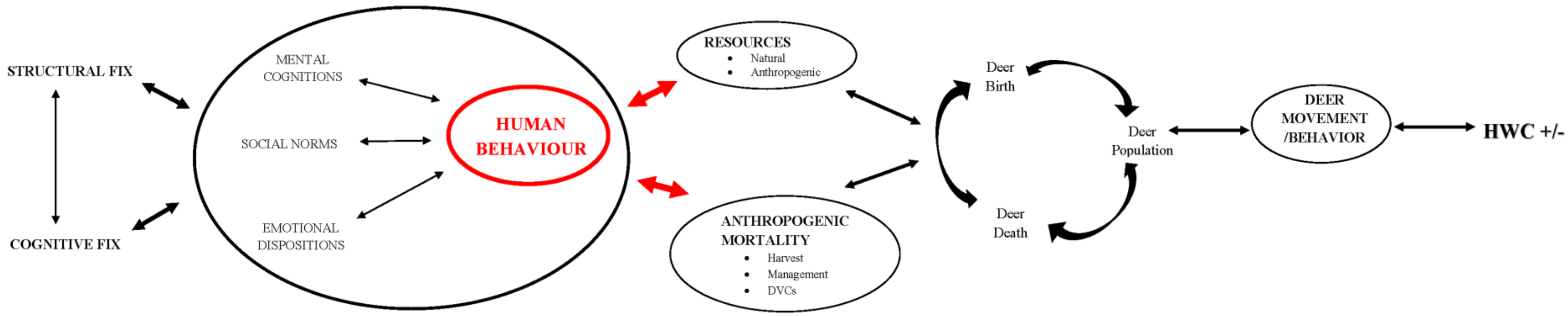

Figure 6.1: Urban Deer Dynamics Model

The urban deer dynamics model represents the relationships between human behavior and WTD population dynamics. Fundamentally, human behavior shapes the landscape, determining to what degree natural habitat is converted or retained. When and to what degree landscapes are modified (natural to develop) is determined by humans at a frequent and rapid rate (see Chapter 1). Human behavior determines the availability of resources, both natural and anthropogenic, and influences herd dynamics such as mortality through harvest parameters, the distribution and abundance of predators located within a geographic area, and even disease, by translocating animals throughout the globe. Research presented in Chapter 4 reveals the degree to which the human behavior of intentionally supplying artificial food sources to urban deer influences their movement and the density of collared deer location points. Readily apparent is the degree to which human behavior influences urban deer dynamics, either positively or negatively. Chapter 5 reveals the positive correlation between human behavior, urban deer movement and density, and the location and frequency of human-wildlife conflict. A key factor in 'wildlife' management and the mitigation of human-wildlife conflict (HWC), therefore, is the management of human behavior. Understanding the emotional dispositions and mental cognitions that influence human behavior, and that drive the system, is essential for management. Chapter 4 one-on-one interview findings expose the importance of better understanding human behavior and emotions and their link to management. Chapter 4 findings reveal the limitations in cognitive fixes as a management approach and the subsequent promise for structural fixes in modifying human behavior in a community such as the GWA. Within the GWA, structural fixes therefore offer the most promise for management, through the establishment of policy and the enforcement of compliance, whether that policy be municipal bylaws prohibiting the artificial and intentional supply of food for wildlife, or something more substantial, such as development parameters that mandate capacities on land conversion.

The development of the structural fixes necessary to manage urban wildlife and create spaces designed for species co-existence will likely require collaborative efforts and the synthesis of knowledge across multiple boundaries (academic disciplines, levels of government/agencies, and political affiliations, to name but a few). Within the GWA, the management of WTD falls under provincial jurisdiction, while the establishment and enforcement of bylaws to manage human behavior is a civic responsibility. Collaboration is therefore required across various levels and departments of government. Establishing an effective framework for decision-making and arriving at a united vision for resource and land management may prove challenging.

6.3 GWA Deer Management Considerations

Based on the knowledge acquired in association with this research, the following considerations for the management of the GWA urban WTD herd are offered:

1. Attitudes matter. Although attitudes are difficult to pin point and hard to change, they are essential to environmental solutions (Heberlein 2012). Managers attempting to embark on urban deer management within the GWA

should consider past resident surveys (e.g. McCance 2009) which offer the opportunity for managers to navigate the most acceptable path toward agreeable and effective solutions (Heberlein 2012).

2. Structural fixes offer promise for urban wildlife management. Several jurisdictions within Canada have used structural fixes with successful results. The City of Kimberly, B.C., as an example, has enacted and enforced a bylaw restricting the supply of artificial food sources for deer. The fines associated with non-compliance of this bylaw are substantial enough to modify resident behavior (Hesse 2009). In other jurisdictions, financial incentive-based programs have been used with success to promote site-specific deterrents and prevention measures on privately owned properties (University of Nebraska 2009) (planting less desirable flora species, fencing where appropriate, dogs to manage golf courses/airport spaces). Structural fixes also offer promise in modifying driver behavior to mitigate DVCs.
3. Norms can powerfully influence behavior (Herberlein 2012). History has shown (example: the "anti-litter" norm), that injunctive norms can be powerful and effective in modifying human behaviour (Heberlein 2012).
4. Management should be conducted at the appropriate geographic scale. Given the nature of GWA urban deer movement and home range size, management of the urban deer herd should be localized in areas where human-wildlife conflict prevails.

5. Land use planning within the GWA should consider an urban growth boundary (similar to Portland, Oregon) with the enhancement of existing, and the creation of new, habitat linkage corridors. These corridors should include site-specific management in key areas, such as wildlife road crossings (as is the case in Edmonton, Alberta). In the absence of readily supplied artificial food sources and site-specific deterrents and prevention measures on private property, in combination with the enhancement of habitat connectivity and urban/rural naturalized spaces, deer within the GWA may re-distribute. Within these urban-natural fringe zones, management should aim to support a fully functioning ecosystem. As in the City of Calgary, Alberta, a healthy urban coyote population, in part, helps to keep the urban deer population in balance (Hess 2009; Alexander & Quinn 2011). These urban-natural interfaces may lend themselves, more realistically, if necessary, to controlled/regulated hunting (given the current distribution of the GWA urban deer in residential backyards, controlled/regulated hunting is not likely a viable option). Currently, new urban development underway within the southwest portion of the GWA lends itself to such opportunities.
6. Should human-deer conflict in the future within the GWA require additional management, beyond those already outlined, community leaders should consider hiring and training a professional team of hunters to selectively remove deer from the GWA urban deer population. Creative options should be considered for the harvested meat. Harvested venison could be sold in

local city markets that promote a local, homegrown renewable resource that provides alternatives to feedlots, growth hormones, and chemicals. Revenue acquired from the locally sold meat could be directed toward urban natural resource programs. Such a management program, in combination with additional previously mentioned management options, offers GWA residents improved opportunities to acquire locally grown meat products (see 100 mile diet: http://www.arch.umanitoba.ca/greenmap/pages/GM_KR_100mile/pages/1.html while also supporting a healthy urban deer population.

7. Although a cognitive fix is not likely to modify human behavior in a suitable timeframe, education and information are key to acquiring support and funding for management.
8. Funds should be allocated to continued social and ecological research, monitoring, and reporting with respect to the GWA urban deer herd.

6.4 Research Limitations

GPS-supported urban deer movement studies that incorporate an investigation of human behavior, wildlife value-orientations, and discrete emotions are limited. While a well-conducted short term evaluation is likely more meaningful than no evaluation at all, there are limitations associated with a study that uses a smaller sample size and is conducted over a two or three year time frame.

Trends in urban and rural deer movement patterns, habitat use, and migrations may fluctuate from year to year depending on numerous variables (resource availability, temperature, precipitation etc). Ideally, ungulate movement studies should aim to maintain a consistent annual sample size, and dependent on the research objectives, should aim to be comprised of a minimum of 20 collared animals/cohort (McLoughlin et al. 2003). Additionally, ungulate movement studies should be conducted over a minimum 5-year time span (Singh et al. 2012; Pritchard et al. 2013) to account for natural variation and seasonal fluctuations. This doctoral research was limited by the acquisition of adequate funding necessary to support larger and consistent sample sizes in both urban and rural cohorts over each year of the study, securing the manpower necessary to manage a project of this size, and by PhD program time constraints. Therefore, this study was limited to smaller sample sizes and constrained to a 3-year data collection period. Further to these challenges were the limitations inherent within an urban environments, where WTD capture and handling was bound to winter ground trapping methods. While the sample size and duration of the study were narrower in scope than would have been desired, the overall information derived from this research is valuable locally as well as regionally, building on existing available knowledge.

Moreover, using Clover box traps to ground capture WTD within the GWA required deer to be lured by bait in order to be collared. Given that this study was designed to investigate urban deer movement and as such, to lead to an investigation of urban deer tendency to be drawn to artificial food sources, this method of capture led to a bias, in that collared animals had already lent themselves to being lured, and being fed from, an artificial food source.

Further, a desire for annual blood samples from WTD as a part of the TB research program in RMNP, WTD were collared during the winter of 2011, and programmed to drop after one year, with a second cohort collared in the winter of 2012, programmed for one year. As a result of the two separate cohorts used each year, limitations may be inherent in the data, specifically in assessing variables such as migration, given that animals were collared for a partial winter season of one year and a partial winter season of the consecutive year (based on animals surviving the duration of a year).

While this research integrates ecological, biological, and social sciences, I contend that the research could have been further enhanced through the incorporation of knowledge from additional disciplines of study, such as anthrozoology, animal ethics, and philosophy, among others. Developing an enhanced understanding of these complex fields, including the history of human-animals relations, and how this shapes present-day human-animal relations, would greatly augment this research and assist wildlife managers in designing management strategies that are most likely amendable to long-term success.

Lastly, while a critical case approach highlights information-rich cases that make a point, quite dramatically, and therefore lead to logical generalizations that can be derived from the evidence produced in studying even a single, critical case, enhanced sample size of those interviewed may offer further validation to research findings. Given the challenges posed by conducting applied social science research, this project was designed to attempt to reduce bias and ensure subjectivity; however, generalizations of research findings across a broader spectrum may be limited.

6.5 Questions for Future Research

Should efforts aimed at mitigating the intentional artificial feeding of urban deer be pursued in the GWA, conducting a similar urban deer movement study in the future may be of value in answering the question of "*Whether urban deer movement patterns, habitat use, and home range sizes change in the absence/reduction of intentionally artificially available food sources"*.

Of further interest is gaining an understanding of the effectiveness of structural fixes at modifying human behavior in comparison to cognitive fixes. Based on the existing literature, cognitive fixes, while an important component of an overall management program, are not likely an overly effective tool in modifying human behavior over what managers may consider a reasonable timeframe. Research, in a community such as the GWA, representative of a number of metropolitan residents providing an intentional artificial food source to urban deer, may offer an interesting case study for assessing the effectiveness of a management program that adopts structural fixes (civic bylaws prohibiting the intentional feeding of urban WTD and fines for non-compliance) and relies on injunctive norms to modify human behavior.

Subsequent studies could aim to determine *"What is the effectiveness of structural fixes in modifying human behavior"?* In gaining an understanding of whether structural fixes offer promise for urban wildlife management, a subsequent research question emerges with respect to the role of structural fixes in facilitating urban species co-existence. Further, an ensuing investigation into the value-orientations and emotional dispositions of urban residents residing in a post "artificial feeding environment" may be informative to assess "W*hether, based on human behavioral changes as a result of enforced structural fixes within a community, there are also associated differences in the wildlife value orientations and emotional dispositions before and after management, and if so, within what timeframe".* Such an investigation may shed light on the degree to which norms (social/injunctive) influence human value orientations and emotions.

Of further interest, is the extent to which human behavior may influence human-wildlife conflict, in this case, DVCs. In a community such as the GWA, where deer movement, the occurrence of human-wildlife, and the occurrence of human-human conflict are influenced by human behavior, future research aimed at the examination of *"Whether in absence of the human behavior of providing intentional artificial food sources for urban WTD, the incidence and/or location of occurrence of human-wildlife conflict within city spaces changes."* Such an investigation may facilitate better understanding of human-wildlife conflict in urban spaces.

Lastly, as various scholars begin to challenge the spatial orderings and the traditional boundaries that humans have constructed with respect to animals occupying the landscape, the body of work on human-animal relations expands, and landscape architects creatively re-think spaces designed for species co-existence, a fundamental and imperative need to bridge the gap between these numerous disciplines (philosophy, ecology, biology, anthropology, humanities, social sciences, architecture, land-planning) will increasingly prevail. Future researched aimed at developing a framework that enables collaboration and a synthesis of knowledge and that translates into practical and feasible species and land management will prove critically important.

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Appendix A: Animal Care Utilization Protocol, Reference F09-034

UNIVERSITY OF MANITOBA | OFFICE OF RESEARCH SERVICES
Office of the Vice-President (Research)

CTC Building
208 - 194 Dafoe Road
Winnipeg, MB R3T 2N2
Fax (204) 269-7173
www.umanitoba.ca/research

November 12, 2009

TO: Dr. Richard Baydack, Environment and Geography., 255 Wallace Building

FROM: Dr. H. Aukema, Chair, Fort Garry Campus Protocol Management and Review Committee

RE: **"Understanding Urban White-Tailed Deer Movement in the Greater Winnipeg Area"**

Please be advised that your Animal Care Utilization Protocol, reference **F09-034**, has received **approval** by the Fort Garry Campus Protocol Management & Review Committee and is valid until **November 30, 2010**. The procedures described by you in the protocol have placed this research in the Category "C" of invasiveness.

It is understood that these animals will be used only as described in your protocol. The protocol must be kept current. Should changes become necessary, very minor alterations can be made with the prior written approval of a university Veterinarian and written notification of the Chair of the Fort Garry Campus Protocol Management and Review Committee. More substantive changes will require resubmission to and reassessment by the Fort Garry Protocol Management and Review Committee. If approved, this will result in the assignment of a new protocol reference number.

Failure to follow this protocol, or renew it prior to the expiry date, will result in the termination of your ability to continue using or ordering animals. The protocol reference number must be used when ordering animals.

HA/tvo

copy: Veterinary Services
Jackie Nelson, BS AHF
Ms. T. Whittington, PAM/Ed. Tech

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September 21, 2010

TO: Dr. R. Baydack, Department of Environment & Geography
255 Wallace Building, 125 Dysart Road

FROM: Dr. H. Aukema, Chair, Fort Garry Campus Protocol Management and Review Committee

RE: **Renewal of Protocol F09-034**

Please be advised that your request for renewal of your project entitled **"Understanding Urban White-tailed Deer Movement in the Greater Winnipeg Area"** (category of invasiveness "**C**"), has been approved for the period ending **November 30, 2011. The reference number for this protocol is now F09-034/1.** The protocol reference number must be used when ordering animals.

It is understood that these animals will be used only as described in your protocol. The protocol must be kept current. Should changes become necessary, very minor alterations can be made with the approval of the University Veterinarian, provided that the protocol in Central files is amended appropriately. More substantive changes will require resubmission to and reassessment by the Fort Garry Campus Protocol Management and Review Committee. If approved, this will result in the assignment of a new protocol reference number.

Failure to follow this protocol, or renew it prior to the expiry date, will result in the termination of your ability to continue using or ordering animals. **Please be advised that only three renewals are allowed. Subsequently, a full application must be submitted.**

HA/ck

c.c. Ms. J. Nelson, Department of Biological Sciences
Veterinary Services
Ms. T. Whittington, PAM/Education Technician

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Appendix B: Letter sent to GWA Residential Households

UNIVERSITY OF MANITOBA

Department of Environment

220 Sinnott Building

70A Dysart Road

Hello,

My name is Erin McCance and I am a doctoral student at the University of Manitoba. I am writing to ask for your participation in a one-on-one personal interview. I am conducting research on the urban white-tailed deer population here in the Greater Winnipeg Area (GWA). I am contacting you because one of the GPS collared deer has been spending time on your property. Since you are in direct contact with deer, your opinion is important to my work. I would like to ask if you would be willing to sit down with me, at your convenience, so I might learn more about (GWA) residents' attitudes, concerns, and preferences toward the urban white-tailed deer population and potential urban white-tailed deer management options. Interviews will be conducted with selected residents residing in GWA neighborhoods with higher deer density. This study has been approved by the Joint Faculty Research Ethics Board at the University of Manitoba. Results from this interview will contribute to my PhD thesis. In addition, interview results will provide valuable information for community leaders accountable for the health and safety of humans and deer and those responsible for reducing human-deer conflict. I am asking for your help to better understand what your values are toward urban deer and urban deer management.

Your participation in this interview is voluntary. However, your opinions, and values are extremely important and your participation will help my research significantly. The interview will take about 1 hour to complete. You are under no obligation to participate and you may stop at any time during the interview process. I will be in contact with you within two weeks' time by phone to answer any questions you may have concerning the interview procedure. Should you choose to participate in the interview, we will then be able to schedule a suitable time on the phone for the interview to take place. To balance demographics, I am requesting that the participant in the interview be the individual in the household who is over 18 and whose birthday is next to occur.

<u>Your responses are confidential.</u> During the interview notes and a tape recorder will be used to record data. All records will be kept in a locked filing cabinet in a private locked office at the University of Manitoba and will be released only as study summaries in which no individual responses and no individual names can be identified. There will be a numerical code associated to each interview that will allow me to associate your opinions only with a geographical area within the city. Upon completion of the study only raw data will be kept and all contact information will be destroyed.

Your participation in the interview indicates that you have understood the information regarding your involvement in this research study. By participating in this interview you in no way waive your legal rights nor release the researcher, sponsor, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and/or you may refrain from answering any questions you prefer to omit, without consequence or prejudice. You should feel free to ask for clarification or new information throughout your participation. Should you have any questions or comments about this study, you may contact me via email at ummccanc@cc.umanitoba.ca or you may contact the Human Ethics Secretariat at (204) 474-7122 or email Margaret_bowman@umanitoba.ca. I would like to acknowledge the support of the University of Manitoba, Manitoba Conservation, and Manitoba Hydro.

Thank you for being a part of this important research.

Sincerely,

Erin C. McCance

BSc., M.Env., PhD Candidate

University of Manitoba

Appendix C: Guiding Questions for Personal One-on-One Interviews

Date:	
Address of Interview:	
GWA Resident Name:	
GWA Resident Contact Information:	
Person Conducting Interview:	
Time Interview Started:	
Time Interview Ended:	

General- Deer on Property	
1	Tell me about your experiences with the deer that have visited your property in the last month?
2	Have you experienced any conflict related to deer? Describe.
3	Do you think there has been a change in the number of deer in your area over the last decade or since you moved into this area? If so, why do you think the numbers of deer may be changing?
4	Do you believe that deer impact the city either positively or negatively? How?

Emotions	
5	Describe how you feel about deer residing in your neighborhood?
6	Describe how your feelings when you see deer on your property.
7	Describe how you think your neighbors feel about deer on their properties and in their neighborhoods?
Management	
8	Are you aware of any deer management that is currently in place for deer residing in the GWA? Describe.
9	Do you believe that managing agencies make good decisions about deer management in the GWA? Why or Why not?
10	Please describe what you would like to see in regard to deer management in the GWA.
Feeding	
11	Do you have any food sources on your property that may be attracting deer? If so, describe what those might be. **(If the answer to this question is no, please proceed to question 22)**
12	How often are you supplying deer with food?
13	How much money do you spend on food for deer in a week or a month?
14	Why do you feed deer?
15	What feelings do you have when you are feeding the deer? What feelings do you have when you see the deer feed from the food you provided?

16	How would you feel if I told you the following facts about feeding deer? Would this information change your mind to not feed deer? Why or why not? a. May increase the occurrence of deer-vehicle collisions b. May change the natural behaviors and movement patterns of deer and may artificially balloon the population c. May result in aggression/fighting between deer d. Subordinate deer may die from starvation e. Fawns may not learn from mature adults where to go to find good wintering cover f. Fed deer may never return to wintering cover, and it is cover, not food that is the most important factor for the winter survival of deer g. May result in disease transmission h. May result in un-natural congregations of deer in one area resulting in localized damage to vegetation on neighboring properties
17	If the City of Winnipeg passed and enforced a by-law against feeding wildlife (including deer), would this change your behavior to stop feeding deer? Why or why not?
18	Would the magnitude of the fine make a difference? $100 vs. $500?
19	If your neighbors expressed frustration toward having deer on their property that may be drawn into the area due to the un-natural food sources you are offering, would this change your actions to stop feeding deer? Why or why not?
20	What would be the best strategy managers could adopt (from the ones mentioned here to any others not yet discussed) that would encourage you to stop feeding deer? What is the "best" strategy that would make you change your behavior?
21	What makes you continue to want to feed deer? **(Continue to Demographics)**
Those that do not feed deer:	

22	If you do not feed deer, why do you think deer visit your property?
23	Do you have neighbors that you suspect are feeding deer?
24	How do you feel about your neighbors that feed deer?
25	Why do you think they feed deer?
26	What do you think would make them stop feeding deer?
27	Have you ever participated in a public meeting or voiced your opinions in another way with respect to deer management in the GWA?
Demographics	
28	How long have you lived in the GWA?
29	Did you grow up in a rural or urban area?
30	What is your highest level of education?
31	How long have you lived at this property?
32	Describe your experiences with wildlife growing up.
33	How did your parents view wildlife growing up?
34	What year were you born?
Others	
35	Lastly, do you have any additional comments that you would like to add?

Appendix D: Human Ethics Approval Protocol #J2009:116

APPROVAL CERTIFICATE

09 October 2009

TO: **Erin C. McCance** (Advisor R. Baydack)
Principal Investigator

FROM: **Wayne Taylor, Chair**
Joint-Faculty Research Ethics Board (JFREB)

Re: **Protocol #J2009:116**
"Understanding Urban White-tailed Deer Movement in the GWA"

Please be advised that your above-referenced protocol has received human ethics approval by the **Joint-Faculty Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement**.** This approval is valid for one year only.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- **if you have funds pending human ethics approval, the auditor requires that you submit a copy of this Approval Certificate to Eveline Saurette in the Office of Research Services, (e-mail eveline_saurette@umanitoba.ca, or fax 261-0325), including the Sponsor name, before your account can be opened.**

- **if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.**

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/ors/ethics/ors_ethics_human_REB_forms_guidelines.html**) in order to be in compliance with Tri-Council Guidelines.**

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208 - 194 Dafoe Road
Winnipeg, MB R3T 2N2
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RENEWAL APPROVAL

September 9, 2010

TO: **Erin McCance**
Richard Baydack
Principal Investigator

FROM: **Brian Barth, Chair**
Joint-Faculty Research Ethics Board (JFREB)

Re: **Protocol #J2009:116**
"Understanding Urban White-tailed Deer Movement in the Greater Winnipeg Area"

Please be advised that your above-referenced protocol has received approval for renewal by the **Joint-Faculty Research Ethics Board**. This approval is for one year only.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

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RENEWAL APPROVAL

August 12, 2011

TO: **Erin McCance**
Richard Baydack
Principal Investigators

FROM: **Wayne Taylor, Chair**
Joint-Faculty Research Ethics Board (JFREB)

Re: **Protocol #J2009:116**
"Understanding Urban White-tailed Deer Movement in the Greater Winnipeg Area"

Please be advised that your above-referenced protocol has received approval for renewal by the **Joint-Faculty Research Ethics Board**. This approval is for one year only.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

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