WALKING POTATOES & WILDER-BEASTS: AN EXAMINATION OF THE SOCIO-ECOLOGICAL RELATIONSHIP BETWEEN HUMANS AND MAMMALS IN URBAN AGRICULTURE

Elle Buckvold-Beirne

A THESIS SUBMITTED TO
THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF ARTS

GRADUATE PROGRAM IN GEOGRAPHY
YORK UNIVERSITY
TORONTO, ONTARIO

June 2024

Abstract

This project explores the positive and negative interactions and conflicts that arise between the people and mammals working, visiting, and living in urban farms and community gardens. This involved an anonymous survey of people that work and grow in the research sites, and the use of trail cameras to capture the mammals that visited the sites. The study examined two urban agricultural sites from August to November 2022, in Toronto, ON: one urban farm and one community garden, both with proximity to urban wildlife habitat.

Growers have a complicated, nuanced relationship with the various species living in and benefitting from these miniature agricultural landscapes. Trail cameras at both sites captured numerous species, as well as several individuals who made repeated visits. Conflicts at both sites arose from the eating and spoiling of crops, and damage to infrastructure by wildlife, but some participants felt positively about their interactions with some species.

Keywords: urban agriculture, urban agroecology, urban wildlife, mammal behavior, urban species richness, sustainability, urban planning, urban food systems, sustainable food systems, urban habitat restoration, urban conservation, urban socio-ecological relationships, socio-ecological relationships, human-nature relationships, human-wildlife relationships, human-mammal interactions, human-wildlife interactions, human-wildlife conflict and coexistence, human-wildlife conflict, human-wildlife coexistence, ecosystem services, environmental understanding, urban camera traps, camera traps, urban camera trapping, striped skunk (mephitis mephitis), coyote (canis latrans), Eastern grey squirrel (scuirus carolinensis), opossum (didelphis virginiana), white-tailed deer (odocoileus virginianus), rats (rattus rattus and rattus norvegicus), american mink (neogale or neovision vision), groundhog (marmota monax), raccoon (procyon lotor)

Dedication

This work is dedicated in particular to my mom, for her unwavering love, support and the joy and inspiration she brings to my life – thank you for taking those phone calls, even when they were at 3-4-5AM, thank you for showing me how to greet the world with an open heart; and to my husband, who makes my life a chaotic, incredible adventure, and without whom I would be even more lost – thank you, let's remember the Scaffolding & the Tides, darling. To my grandparents, in gratitude for their stalwart belief in the value of education, knowledge and learning, for their awe-inspiring example, and of course, their love. Specifically, Grampa, thank you for being a lighthouse on a steady shoreline, measured in your words and in your actions, setting an example of calm, loving, intelligence. And Mema, thank you for being the whip-smart, fiery, elegant, brave woman you are – may we all have adventures such & age as gracefully as you. To my aunt, who works to inspire others daily, and regularly inspires me to fight the good fight. To my friends, near and far, most especially Dom, for keeping my head on straight throughout the years; Vova, for listening, commiserating and bringing back laughter; Wiley, for their academic prowess, understanding & alternate point-of-view; Aoife the Tormentor, for the laughter, the pints & the reinforcement to always fight for yourself; and more the world over for the joy and the pick-me-ups. It is also dedicated to the animals who have graced my life with their lifetimes and their love; Rugrat, who was gentle; Amber, who was kind; Magical Mister Mistofelees, my garden Lion; Java, my darling Panther, forever holding a piece of my heart; and Whiskey, who, for now, is young, wilful and Double-Thick.

This research is for my nieces – who bring me so much joy in their childhoods, as they learn, grow and begin their own paths through life. If they ever read this, I hope they know that I love them immensely, and have thoroughly enjoyed being their Aunty Elle. This research is for the future. It was undertaken in the hope that we can find a way forward that balances our needs and desires with the necessary understanding, care and relationship with the world around us. This project was loved, hated, and meticulously *worked over – the author has thought of little else for over two years, and, as such it is also dedicated to those that read it – I hope those that do, learn something from it.*

Acknowledgements

I would like to acknowledge the farmers, growers and site administration for engaging with my research, the support of my supervisor, Dr. Justin Podur, and my committee member, Dr. Gail Fraser, as well as the research assistance I received from Justin Chan. Additionally, I would like to acknowledge the support I received of grants from York University and the Canadian Association of Geographers.

Table of Contents

List of Tables

List of Figures

1. Introduction

Climate change is wreaking havoc on the environment worldwide, impacting agricultural and urban landscapes, as well as biodiversity and the behaviours of animals. Cities are increasingly focused on sustainable development, and creating or reworking the landscape to be greener, with multifaceted uses and environmental services. Academic research often falls into two main categories, the social and the scientific, but increasingly it needs to bridge the gap, to create more nuanced, interdisciplinary research in a complex and changing world. Urban geography is uniquely suited to work with urban ecology to begin understanding and solving the issues arising. These two fields are particularly suited to each other, with both fields currently acknowledging a need for the other – geography, for social science to be paired with environmental science, (Herbert & Matthews, 2004; Lorimer, 2012) and vice versa, ecology, to integrate social science with biological and behavioural science, (Collins et al., 2021; Magle et al., 2012). These fields are somewhat merged in the study of agroecology, and the nascent urban agroecology. Urban agroecology seeks to understand urban agriculture as a socio-ecological system, comprised of interdepending social institutions and biologic/physical factors and processes, (Ong & Fitch, 2020). Balancing our needs for urban crop production and species' needs for foraging and living space requires a social and ecologic understanding of urban agriculture. Following a similar framework, this research explores two main fields, urban agriculture and urban wildlife. Urban agriculture envelops both urban farms and community gardens, and is rarely studied as both a social and environmental impactor, and even less studied as habitat for urban wildlife. This research engages with urban wildlife research across three facets – human-wildlife interactions, mammal behaviour, and species richness in urban agriculture. These fields are of critical importance to our world now, and in the immediate and distant future.

This research examines the social and the ecological impacts of two urban agriculture sites in Toronto, Ontario, Canada. The focus of this study is the examination of the mammal species, their behaviours, and the reactions of the growers in these urban agriculture sites, to develop a foundational understanding of the relationship(s) between growers and mammals. Conflict and coexistence are found in abundance at these sites, along with a sampling of the usual urban exploiters, and some unexpected urban adapters[1]. Central to this thesis are three main questions: 1) What mammal species are detected in urban agriculture spaces? 2) What behaviours are they exhibiting while there? 3) What is the reaction of growers to mammal species in urban agriculture? As such, this thesis examines three hypotheses: 1. There is a difference in reaction to mammals by growers in community gardens vs. farmers in an urban farm, one of these subsets of stakeholders will have a stronger negative reaction to mammals in urban agriculture than the other. 2. There is a significant difference in the mammal community at Maloca Community Garden compared to FreshCity Urban Farms, impacting the human-mammal interactions and relationship on-site. 3. The human-mammal relationship in urban agriculture is one based on conflict over resources and infrastructure, with occasional tolerance for certain charismatic species. These questions and hypotheses interlace to expose the relationship between growers and mammals in urban agriculture.

An examination of the current, relevant literature in the fields of urban agriculture and urban wildlife further contextualises the necessity and results of this research. Beginning with urban agriculture (UA), studies of the social and environmental impacts of these projects are discussed. There are many documented benefits of UA, including improvements to individual health and community, economy, cooling, runoff retention,

[1] Identifying species as urban avoiders, adapters and exploiters was first presented applied to bird species by Robert Blair in 1996, and has become a more or less accepted identifier for species tolerance of urban living, (Alagona, P. S. (2022). *The accidental ecosystem : people and wildlife in American cities*. University of California Press. , Blair, R. B. (1996). Land use and avian species diversity along an urban gradient. *Ecological applications*, *6*(2), 506-519. , Tryjanowski, P., Morelli, F., & Møller, A. P. (2020). Urban birds: Urban avoiders, urban adapters, and urban exploiters. In *The Routledge Handbook of Urban Ecology* (pp. 399-411). Routledge. , Łopucki, R., Klich, D., & Kitowski, I. (2019). Are small carnivores urban avoiders or adapters: Can they be used as indicators of well-planned green areas? *Ecological indicators*, *101*, 1026-1031.)

and more, (Egerer & Cohen, 2020). The most relevant fields of urban wildlife literature are urban biodiversity, urban wildlife behaviour, and human-animal relationships. These fields are examined in conjunction with each other and urban agriculture, as they are interlinked throughout the course of this research. Additionally, literature around the proper amount, type, use and deployment of camera traps in ecology research is discussed, as relevant to the methods of data collection.

Toronto is the most populous city in Canada, and one of the most in North America. Due to its size, sprawl and population, it is a prime location for research on urban environment, ecology, geography and sustainability. Two field sites were chosen for this study, one community garden, Maloca Community Garden (MCG), and one urban farm, FreshCity Urban Farms (FCUFs). Both are within Toronto, nestled within larger greenspaces, and have some proximity to each other. These features ensured continued access to each site, an increased probability of grower-mammal interactions, and a likelihood of similar species variety without territory overlap. Maloca Community Garden is smaller, and mostly individually or family managed, with some shared growing space. FreshCity Urban Farms is one site geographically, sharing a fence line, greenhouses and some infrastructure, but fields are divided between NGOs and community farming groups. Both sites are longstanding urban agriculture projects, with a third of respondents involved for a year or more.

This study was twofold, with parallel research determining the species and behaviour of mammals, and the thoughts and opinions of growers. First, camera traps were deployed at each site and moved weekly, to photograph mammals on site. Then photographs were examined to determine the species richness, and behaviours of mammals visiting and living in the field sites were further analysed. Fourteen species were identified in photographs taken onsite, with two main categories of behaviour – foraging and denning. Second, information about MCG and FCUFs, and the thoughts and opinions of growers/stakeholders were assessed through questionnaires collected at both sites. Responses showed some trends among growers, but responses per site were not comparable. Contrasting with expectations, growers were much more moderate in their responses to mammals, somewhat accepting of their presence, acknowledging damage and pest behaviors, but also admiring certain aspects of species.

The relationship between growers and mammals is complicated, but not fully biased toward conflict, as coexistence appears to be a key feature of urban agriculture. Growers and mammals were in conflict over produce and infrastructure, but there was also a level of acceptance of mammals and their destruction by growers. There was an apparent understanding and recognition of species' right to live and visit these spaces as much as growers' right to grow and harvest produce. Mammals were much more interested in the resources available at each site than defending it from the humans who had grown and built it.

This thesis is structured as follows. Following this introduction, in Chapter 2, the existing literature on urban agriculture and urban wildlife is reviewed. Chapter 3 contextualises the research setting and presents the methodology, including methods of data collection and analysis. Chapter 4 is the empirical chapter. Section 4.1 focuses on ecologic results, the mammal species richness of each site, and documented mammal behaviours. Section 4.2 focuses on social results, breaking down questionnaire responses. The geographic context of these sites, camera placements and locations of mammal evidence is the focus of Section 4.3. Furthermore, discussion and engagement with previous literature is in Chapter 5, while Section 5.3 entwines the previous results to consider the relationship and dynamics between the growers and mammals in these urban agriculture settings. Chapter 6 concludes the thesis, and Chapter 7 provides relevant references. There are also four appendices after the bibliography, with the research questionnaire, example photographs of documented species at each site, and a set of photographs from photosets that were not examined to the same level of detail.

2. Literature Review

There is a possibility of a commensal or mutualistic relationship between urban agriculture and wildlife. While there is considerable work on the benefits of urban agriculture, the proliferation of wildlife in the urban landscape, and human – non-human animal relationships, few studies have examined the relationship between the humans and animals that utilize and visit urban agriculture sites. The following will review various areas of urban agriculture and urban wildlife research.

2.1 Urban Agriculture: Human and Environmental Impacts

Urban agriculture refers to both community gardens (CGs) and urban farms (UFs). The distinctions between these two forms, in terms of size of growing area and visitation by stakeholders[2], are not the central focus of this research. Literature surveyed here touches on both community garden and urban farm research.

The wide-ranging benefits of urban agriculture projects have been repeatedly documented, (Delshad, 2022; Draper & Freedman, 2010; Genter et al., 2015; Malberg Dyg et al., 2020; Travaline & Hunold, 2010). Community gardens and urban farms have been extensively studied through two separate lenses, their human impact, and their environmental impact. Previous studies have often fallen into the Nature-Society dichotomy, but this research looks to employ a more holistic, '*Earth Community*' view, (Berry, 1988). The human impact ranges from broad social, economic, and emotional impacts to everyday food security, community building, and relaxation. Environmental impacts begin as a way to localise food production, decrease rainwater runoff, and provide oases for urban wildlife. Urban agriculture projects are considered one of many tools in the urban policymaker's toolbox, and have been used since the 1890s as a solution to a number of urban problems, (Lawson, 2005), ranging from food insecurity to crime, aesthetics, and health, (Brault, 2010; Draper & Freedman, 2010; Lin et al., 2015).

[2] UFs can be more industrial, with more daily visitation as people work on site, with CGs having more variable visitation due to individual schedules.

Recent studies of CGs and UFs have found that they relieve stress and isolation, improve community building, promote healthier lifestyles, facilitate interactions with nature, and support a sustainable urban landscape, (Beilin & Hunter, 2011; Genter et al., 2015; Holland, 2004; Ramsden, 2021).

2.1.1 Social Impacts of Urban Agriculture

The societal benefits of urban agriculture stretch from the economic to the emotional, from health, home value, social and cultural cohesion, and children's development, and exist across demographics, (Alaimo et al., 2008; Baker, 2004; Beavers et al., 2020; Draper & Freedman, 2010; McCabe, 2014; Ohmer et al., 2009; Soga et al., 2017; Van den Berg et al., 2010; Voicu & Been, 2008). Individual health and happiness are already greatly improved by being in a greenspace, (Dyment, 2005; Konijnendijk, 2012; Maller et al., 2006). This positive effect is further amplified by the ability to directly interact with nature and harvest fresh produce that urban agriculture provides. Gardening has been found to be good exercise for both young and old, as well as increasing fruit and vegetable intake, (Alaimo, Beavers, et al., 2016; Alaimo, Crawford, et al., 2016; Alaimo et al., 2008; Beavers et al., 2020; Hermann et al., 2006; Ober Allen et al., 2008; Park et al., 2014; Van den Berg et al., 2010). These benefits, combined with increased social and natural interactions, and decreased isolation, promote a mental health boost as well. Growers have lowered levels anxiety and depression, and even of the stress hormone cortisol, (Poulsen et al., 2014; Soga et al., 2017; Van Den Berg & Custers, 2011; Wakefield et al., 2007). Community gardens can even support a decolonized strategy for healthy living, (Hanbazaza et al., 2015; Mundel & Chapman, 2010).

Urban agriculture increases property values and food security, while decreasing household food costs, (Furness & Gallaher, 2018; Voicu & Been, 2008; Wang et al., 2014). Community gardens also support the building of strong community social bonds, which leads to stronger civic engagement, cultural or social cohesion, and lowering crime rates (Bailey & Kingsley, 2020; Baker, 2004; Firth et al., 2011; Kondo et al., 2016; Lee et al., 2022; McCabe, 2014; Teig et al., 2009; Veen et al., 2016; 'Yotti'Kingsley &

Townsend, 2006). This shows that urban agriculture is not only a farm or garden, but also playground, school, gym, nature therapy, neighborhood meeting point, and grocery shop.

2.1.2 Environmental Impacts of Urban Agriculture

Community gardens and urban farms are also environmentally beneficial. The environmental benefits begin with a localised food cycle, decreased rainwater runoff, improved air quality, city cooling, and support for urban wildlife, (Anderson & Gough, 2022; Clarke & Jenerette, 2015; Clucas et al., 2018; Egerer et al., 2017; Lin et al., 2015; Peng et al., 2015; Travaline & Hunold, 2010). The cooling of the city 'heat island' effect is particularly relevant to increasing resiliency in the face of climate change, (Anderson & Gough, 2022; Okvat & Zautra, 2011). Urban sustainability is positively impacted by CGs and UFs, through collapsing nature-society dualism, improving environmental understanding and protection, and supporting stakeholders' connections to nature, (Egerer et al., 2018; Hawkes & Acott, 2013; Hawkins et al., 2013; Holland, 2004; Travaline & Hunold, 2010).

This plethora of benefits informed the framing of the questionnaire and the analysis of the results. One of the first questions asks if the participants felt the urban agriculture site had a positive or negative impact on them. Additionally, the investigated environmental impacts of the research sites were the species richness and behaviour of the mammals documented on site. Urban agriculture also has a significant impact on, and is significantly impacted by, urban wildlife.

2.1.3 Urban Agriculture impacts on Wildlife

A review by Guitart et al., (2012) noted a lack of natural science research in relation to community gardens, particularly as places of potential biodiversity conservation, (Guitart et al., 2012). Another study by Lin et al., (2015) found that research is needed to understand the effects of garden management on city-wide biodiversity and wildlife movement, (Lin et al., 2015). Clucas et al., (2018) found that more research is needed on the biodiversity and conservation possibilities of small mammals within urban agriculture, (Clucas et al., 2018). Urban agriculture faces challenges to expand food accessibility, ecological support and environmental justice. These challenges will need to be met with research that integrates many disciplines, especially natural and social sciences, (Chappell & LaValle, 2011; Zimmerer et al., 2021). This study investigates the lacunae previously exposed by these studies through an examination of the behaviour, movement and relationships of mammals interacting with urban agriculture sites.

2.2 Urban Wildlife: Biodiversity, Behaviour, Human-Animal Relationships, and Camera Traps

Both the natural world and urban landscapes are complex, chaotic, and full of variety. Urban wildlife – and human–animal interaction and conflict – has been a fact of urban life since the first cities were built, (Soulsbury & White, 2015). Urban regions are fast-growing, highly-modified, anthropogenic landscapes, and are quickly becoming more and more of the available habitat, and existing ecosystem, (Grimm et al., 2008; Rivkin et al., 2019; Seto et al., 2012).

2.2.1 Urban Biodiversity

Urban ecosystems have become a refuge for animals after habitat has been destroyed by urban encroachment, leading to an increase in urban biodiversity, (Faeth et al., 2011; Gallo & Fidino, 2018; Hansen et al., 2020; Ives et al., 2016; Van Patter, 2021). Urban landscapes are likely to hold a larger and larger sect of the biodiversity of our world, as cities grow bigger and the climate continues to change, (Faeth et al., 2011). Threatened and endangered species are also found in cities, making them not only landscapes of biodiversity, but significant landscapes of conservation, (Ives et al., 2016). Thus, in order to better support existing biodiversity, or increase it, cities must develop smarter, greener landscapes, and innovate their landscape design as density increases, (Fidino et al., 2021). Moving beyond traditional conservation areas may help to expand how many species can be supported and conserved, as marginal habitat or multi-use habitat is much easier to plan for than large conservation parks and greenspaces, (Soanes & Lentini, 2019). Overall, urban landscapes can and do support a higher level of species than expected.

Unsurprisingly, urban species are often found in habitat patches, usually golf courses, urban greenspaces, or backyard gardens, (Angold et al., 2006; Fidino et al., 2021; Gallo et al., 2017; Goddard et al., 2010; Grade et al., 2022; Hansen et al., 2020; Manlick et al., 2020; Sperling & Lortie, 2010). Backyard resources, especially supplemental food sources support an increased abundance of urban wildlife, particularly prey species, (Hansen et al., 2020). Additionally, the heterogeneity of habitat can have positive impacts on the coexistence of some species, but can lead to niche-overlap and competition as well, if there is not enough habitat or land-use changes, (Manlick et al., 2020). Mammal species richness has been found to be higher in urban greenspaces that have larger patch sizes, with the same study also documenting a mink (*Neogale/Neovision vision*) in Manhattan, (Bradfield et al., 2022). Furthermore, areas with a combined high level of greenspace land use and anthropogenic resources had higher mammal species richness than both more urbanised or rural land use areas, (Grade et al., 2022). Habitat patches often offer attractants such as food and vegetation cover, both of which is further amplified in urban agriculture. The sites chosen for research are nestled within larger urban greenspaces, increasing the likelihood of a high species richness. Additionally, urban wildlife research shows an emerging trend of co-investigating urban social and ecological issues, (Collins et al., 2021). This trend will be continued in this research, as the biodiversity of mammals will be investigated in conjunction with their behaviour and the opinions and reactions of the growers on site. Furthermore, some areas within the urban landscape are biodiversity hotspots, with a higher likelihood of multispecies interactions, which need further research, (Rega-Brodsky et al., 2022). Urban agriculture is highly likely to be one such hotspot. To date there are few studies of mammalian biodiversity within community gardens or urban farms, and their interactions with the people who create and maintain urban agriculture spaces.

2.2.2 Urban Wildlife Behavior and Human-Wildlife Relationships

The increase in biodiversity in cities has led to changes in mammal behaviour, a rise of human-wildlife interactions, and an apparent bias in the literature toward conflicts, (Fascione et al., 2004; Gehrt et al., 2010; Magle et al., 2012; Niesner et al., 2021; Soulsbury & White, 2015; Taylor et al., 2011). Changes in mammal behaviour include diet, territory size, increased nocturnal activity, vigilance and decreased flight initiation distance, (Lowry et al., 2013; Ritzel & Gallo, 2020). Mammals that live in urban environments seem to have some common traits: avoidance or tolerance of humans, use of the urban matrix to their advantage, omnivorous or opportunist diets, and acceptance/tolerance by people, (Chatelain & Szulkin, 2020). Some species are beginning to adapt to urban life in ways previously unseen, or at least, unnoticed. Raccoons (*Procyon lotor*), red foxes (*Vulpes vulpes*), white-tailed deer (*Odocoileus virginianus*), and coyotes (*Canis latrans*) are particularly infamous for recent adaptation and prevalence in North American urban environments, (Ditchkoff et al., 2006; Fascione et al., 2004; Gehrt et al., 2010; Prange & Gehrt, 2004). Even species that are less infamous are adapting to urban landscapes. Groundhogs (*Marmota monax*) decrease the size of their home-range, and maintain fewer dens, closer together in urban areas than rural counterparts, (Lehrer & Schooley, 2010). Urban groundhogs also have a slight increase in survival, due to an increase in hibernation survival, and a decrease in predation, (Lehrer et al., 2012). Behavioural adjustments are likely a necessary part of urban survival – there are many differences from any species' traditional habitat: more disturbance, less space, and a different abundance and types of food, just to list a few.

Human-wildlife conflict and coexistence is a rapidly expanding, interdisciplinary field, engaging with human and animal behaviour, conservation biology, damage mitigation, and more, (Frank et al., 2019; Nyhus, 2016). Human-wildlife conflicts often arise from the intersections of our behaviour and their behaviour, if garbage is unsecured, or shed doors left ajar, animals are going to make use of those resources. Additionally, some mammals have shown themselves to be especially adept at making use of our leftovers and circumventing our prevention measures. Raccoons (*Procyon lotor*) are known in particular for being excellent exploiters of urban anthropogenic resources, learning new skills in order to forage more efficiently, (Prange & Gehrt, 2004; Stanton et al., 2022). Meanwhile, one of the most ubiquitous urban inhabitants – rats (*Rattus norvegicus or Rattus rattus*), survives in our cities despite our best efforts to control their populations and limit movement, as urban landscapes offer plenty of places to forage and den (Byers et al., 2019). Striped skunks (*Mephitis mephitis*) are another species that is often problematic in the urban environment, as they are known for their defensive spraying of dogs (*Canis familiaris*) and children, as well as being a potential vector of rabies, (Allen et al., 2022). Behaviours that compete with our needs and desires for greenspaces and residential areas are very frustrating to urbanites, and often lead to raccoons (*Procyon lotor*), rats (*Rattus norvegicus or Rattus rattus*), and other species being labelled as 'pests', (Alagona, 2022; Brookshire, 2022; Donovan, 2015). Some species manage to somewhat avoid conflict, or at least avoid the label of pest, through their behaviour or period of activity. Opossums (*Didelphis virginiana*) were found to be exclusively nocturnal, as opposed to racoons (*Procyon lotor*), found to be both nocturnal and crepuscular, (Mims et al., 2022). These behaviours can prevent some conflict through a lack of direct interactions, but are not a perfect solution either. The field of human-wildlife conflict and coexistence will continue to expand as our cities expand, absorbing and creating both more habitat and more species, thus creating a growing need to continuously update our research and understandings, (Soulsbury & White, 2019). Urban wildlife is an entrenched and necessary part of urban life – one that must be understood in order to encourage coexistence, and support sustainable cityscapes into the future.

As mammals move through the cityscape, they make use of the built environment, using underpasses, culverts and greenspaces to move, forage and den in cities, (Niesner et al., 2021). The use of 'our' infrastructure absolutely extends to urban agriculture projects, but so far has not been investigated as a shared-use, social-ecological space. Engaging local communities can support conservation and coexistence with urban wildlife, (Puri et al., 2024; Soanes & Lentini, 2019). Successfully managing human-wildlife conflicts and coexistence requires engagement from local residents in devising and implementing management strategies, (Basak et al., 2023; Puri et al., 2024; Treves et al., 2006). Often, these strategies revolve around changing human behaviours to include mitigations for known or potential wildlife behaviours, and educating residents about the necessity and utility of making these changes (Puri et al., 2024). The changes to human behaviour attempt to prevent animals from becoming or staying problem and pest animals, in order to avoid lethal management. Additionally, wildlife education programs and more intentional engagement with nature often leads to not only a greater understanding, but a greater level of tolerance for wildlife.

Multiple urban ecology and biodiversity studies have highlighted the need to integrate social and natural sciences, particularly to facilitate a better understanding in studies of urban ecosystems, ecology, and geography, (Collins et al., 2021; Lorimer, 2012; Pickett et al., 2001). Research on a wider range of taxonomic groups and urban systems, as well as an emphasis on biodiversity hotspots is needed for a better understanding of urban biodiversity, (Rega-Brodsky et al., 2022). Interdisciplinary research, involving both the social and natural sciences, supports a more holistic approach for the integration of ecology with urban planning, (Niemela, 1999). As an emerging field, shared-use infrastructure illustrates the significance of urban infrastructure on the lives and movement of urban wildlife, which further supports conservation and conflict resolution, (Niesner et al., 2021). The governance and management of urban green spaces for biodiversity and conservation has an increased need to find a way to balance human needs and uses of green spaces with ecological and conservation needs, or even ways to enhance both, (Aronson et al., 2017). Soulsbury and White (2015) highlighted the bias toward conflicts in human-wildlife interactions research, and the widely under-explored niche of the *benefits* of human-wildlife interactions, including the need to work beyond biology and ecology to include social sciences in such studies, (Soulsbury & White, 2015). These studies have underscored the need for an interdisciplinary, nuanced and more positive-focused study of urban biodiversity, infrastructure use by wildlife, and human-animal interactions.

2.2.3 Camera Traps

Camera traps are a widely used, non-invasive measurement technology for a variety of remote environments, (Long, 2008). Camera traps are used to monitor biodiversity, behaviour and other ecological surveys, since their adoption in the 1990s, (Long, 2008; O'Connell et al., 2011; Steenweg et al., 2017). Animal behaviour is sometimes studied as a “bycatch” of camera trap data, (Burton et al., 2022; Caravaggi et al., 2017). This study will utilize photographs for an analysis of two distinct mammal behaviours – denning and foraging. However, in the urban landscape camera trapping is only beginning to be utilised, (Anton et al., 2018). Camera traps can inform levels of animal activity, rough population density, and even support improved human-animal relationships, (Herrera et al., 2021; Rowcliffe et al., 2014; Vella et al., 2021). The amount of camera traps needed differs based on the study area, length of study, and rarity of targeted species, (Kays et al., 2020; Pease et al., 2016; Rovero et al., 2013). Some studies suggested that twenty-five to thirty cameras were needed, and another suggested setting up a 360°-matrix of three to four cameras per station, (Kays et al., 2020; Pease et al., 2016). This study utilized four cameras in total, due to the smaller size of the research sites, and the necessity of moving cameras to avoid damage and theft. Camera traps were particularly useful in this study as many of the mammalian visitors were documented at times where humans were not present, or hid at the approach of the researcher and participants, thus being impossible to properly document otherwise.

If the urban landscape must increasingly become a landscape of sustainability, expanded food accessibility, green infrastructure, biodiversity and conservation, then significant changes must be made – in our landscapes, our behaviour, and our reactions to “problem” wildlife. Urban agriculture and other green infrastructure will need to be increased, to support growing urban populations. Connectivity between greenspaces will need to be maintained and expanded to support wildlife habitat and movement. There must be increased focus on coexistence, and finding spaces where urban wildlife cannot only exist, but thrive with minimal conflict and maximum benefit. Urban agriculture is highly likely to be a biodiversity hotspot, with plenty of marginal and multi-use habitat, in a space that has already been designated as significant for engaging and interacting with nature in the city. Urban agriculture will be key to an equitable human and non-human urban landscape, but so far has not been investigated as a possible place of coexistence and conservation.

3. Research Design, Field Sites, and Methods of Data Collection

3.1 Research Frameworks

This study utilizes an urban landscape ecology framework and a socio-ecological framework. The urban landscape ecology framework focuses on improving the relationship between urban landscape patterns and ecologic processes in order to achieve urban sustainability, (Wu et al., 2013). A socio-ecological framework centers human-nature and human-animal interactions, to foster spaces that welcome and support both our human society and the natural world, (Collins et al., 2021; Cranz & Boland, 2004; Van Patter, 2021). These frameworks allowed the research to move beyond the usual dichotomy of urban geography and urban ecology, toward a more nuanced understanding, an urban 'eco-graphy.'

3.2 Field Sites

Site selection was predicated on two main features: 1) the continuous accessibility of the site to the researcher, and 2) an increased likelihood of human-animal interactions. Two sites were selected, both located in Toronto, Ontario, Canada: The York University Maloca Community Garden (Maloca CG/MCG) and Downsview Park FreshCity Urban Farms (FCUFs). Maloca CG is located on the edge of a large, relatively unbroken creek valley and lacks a large fence to prohibit wildlife encounters. FreshCity Urban Farms is located inside a very large park, with ecologically supportive landscapes. These factors greatly increased the likelihood of increased levels of human-animal interactions.

This research followed a combined survey and case study methodology. A case study framework allows for some integration and potential comparison of the results with a previous biodiversity survey conducted in the Black Creek catchment area in 2010, ((TRCA), 2010). It also facilitates a deeper, nuanced examination of human-animal shared spaces, beyond standard biodiversity, behavior, and social surveys.

3.3 Data Collection Methods

Research commenced on August 24th, 2023, with the placement of four trail cameras. The experiences, opinions and ideas of gardeners and farmers, the human participants, were collected with questionnaires beginning on the same date. Questionnaires are well-established in geography as a way to assess the behaviours, attitudes, and perceptions of participants, (Clifford et al., 2016). The presence, activities, behavior, and experiences of the mammalian participants that visit the sites were collected through biodiversity surveys and the use of camera traps.

The methods outlined are both qualitative and quantitative, as this cultivated the best opportunity to understand both the positive and negative relationship dynamics between humans and animals within the Maloca Community Garden, and FreshCity Urban Farms in Downsview Park. The qualitative data will facilitate the description of the opinions and feelings of the stakeholders about the mammalian visitors they encounter. Meanwhile, the quantitative data will promote an explanation of the mammalian species richness and behavior within the park sites broadly, and the urban agriculture sites specifically.

Once the collected data was analysed, a report was written for each site. These reports provided details of the species visiting the space, the general attitudes of the stakeholders, and any viable mitigation strategies suggested, and were shared with each site.

3.3.1 Ecological Methods

Camera Survey Protocol

Camera traps were used to assess the incidence and behavior of mammals visiting the sites throughout the research period. Four remote cameras were deployed, each as a sampling unit. Two trail cameras were placed at Maloca Community Garden, one

MuddyCam and one StealthCam, and two trail cameras were placed at FreshCity Urban Farms, one MuddyCam and one StealthCam. The remote cameras were onsite from August 24th to November 15th-17th 2023, and the sites were visited weekly. These visits facilitated downloading images from the trail cameras, checking and replacing batteries, and changing camera location, view, and setup. GPS points were taken of each camera setup location, as well as the location of any evidence of animals in the site or surrounding area.

There were twenty camera setups at both Maloca Community Garden and FreshCity Urban Farms, both sites had one camera failure throughout the research period. Each site had one camera location and view repeated, MCG had a second placement focused on the den underneath the shed, and FCUFs repeated placement documented the compost heap at Ubuntu Community Collective. FreshCity Urban Farms, Downsview, had applicable stations for two small 360°-matrix setups, (Pease et al., 2016). In addition to standard one camera – one view setups, two matrix setups, (dual camera – opposite view, near 360°), and one dual camera – intersecting view setup were placed in different locations on FreshCity Urban Farms. These setups were implemented to increase the likelihood of coyote (*Canis latrans*) photo captures, and due to the availability of both adequate open space for view, and suitable mounts. Photographs from the dual camera – intersecting view setup were cross-referenced in order to prevent double counting of species.

Table 1: Camera trap brands and specifications, two sets were purchased and used for the duration of research. One of each model was placed on site, to ensure model differences were a non-factor in potential failures and data loss.

Brand	Model	Trigger Speed	Detection/Flash Range	Burst	Timeout	Price	Picture
StealthCam	STC-QS12ATK *v2*	1.0 second	Sixty-foot	3	10 second	$130, each.	
MuddyCam	MUD-MTC24VK	0.4 second	Eighty-foot	3	10 second	$150, each.	

Presence Evidence Surveys

Presence/absence surveys were conducted on a monthly basis throughout the research period, in order to assess species in and around the site, as some species are camera avoidant. The surveys were conducted by walking with a designated partner at dusk and dawn, for forty minutes to an hour. These walks were fully accompanied, with adequate water and first aid supplies, any mammals that were seen were photographed, and moved away from. Direct interactions were avoided. These surveys primarily documented identifiable pawprints and scat: very few species were actually sighted.

The presence surveys provided a representation of the wider mammalian population in the Black Creek catchment area and Downsview Park, while the camera traps show the specific species interacting with the CG/UF. These species are representative not only to Toronto and Ontario, but many urban and peri-urban areas throughout North America.

Ecological Data Analysis

Camera trap photographs were subject to two modes of analysis. The first was to calculate the incidence of different mammal species and understand the mammalian species richness at both Maloca Community Garden and FreshCity Urban Farms. In order to accurately reflect the species richness and diversity, a 30-minute delay interval was used for each species to ensure independent events by mitigating repeated counting of individuals as much as possible, (Burton et al., 2015; Sollmann, 2018). The number of independent events per species were then used to calculate a Shannon Diversity Index for each site, using the equation: [$H = -\Sigma p_i * ln(p_i)$], (Shannon, 1948; Spellerberg & Fedor, 2003). Due to a few placement errors four datasets were excluded from full analysis, and were instead rapidly reviewed. These datasets were all over 7,000 photographs, and had a view that was too high, full of wind-based plant movement or other issue that reduced the likelihood of any mammal photographs.

The second analysis of photographs was for mammal behavior, particularly assessing foraging or denning behaviors associated with site utilization. This involved analyzing every mammal photograph in a time-series for potential behaviors. Then, photographs that had clear behaviour were further analyzed to determine if the mammal was foraging or denning on site. Mammals documented taking, gathering or eating produce grown on site were considered active foraging. Mammals burrowing or repeatedly entering/exiting an existing den were considered to be denning on site. Some photographs showed both foraging and denning behaviour by certain species, these were counted in both categories, as they are not in direct comparison. A table of behaviour photographs was produced for each site (Chapter 4, Tables 5 and 6; pgs. 32 and 37), and photographs of particular interest are included.

The documented signs of, or encounters with, mammals that live in the Black Creek catchment area and Downsview Park from the biodiversity surveys were used to create an evidence map for each site (Chapter 4, Figures 16 and 17; pgs. 55-56), showing places where identifiable pawprints and scat evidence were found.

3.3.2 Social Methods

The survey of the human participants of this research was limited to those who regularly interact with Maloca Community Garden or FreshCity Urban Farms: stakeholders, e.g., gardeners, farmers, and administration. During the weekly site visits any gardeners or farmers present were given the opportunity to respond to the questionnaire. The questionnaire centered on the experiences and opinions of the gardeners and farmers as they see or interact with mammals in the site. The questionnaire began with closed questions, using a rating scale to assess positive and negative attitudes to various aspects of urban agriculture and animal interactions at Maloca CG and FreshCity UFs, (McLafferty, 2003). A few open-ended questions were also included to allow participants to include more detail, and to suggest mitigation strategies for negative human-animal interactions. The questionnaire used for this study can be found in Appendix A. The combined responses are representative of the study areas, but are not large enough to be considered generally indicative of any trends, nor are they particularly comparable. Due to the relatively small human sample size, questionnaire data was managed and analysed with the use of Microsoft Excel. Responses were coded, with the responses to open-ended questions grouped by theme.

Ethical Considerations

Ethical considerations in this study revolved around ensuring the anonymity of the participants, and those in camera trap photographs. One of the priorities of this study was ensuring privacy, while encouraging engagement from stakeholders. Camera trap photography is considered to be a non-invasive study method, (O'Connell et al., 2011). The camera traps used in the study are quiet, with an infrared flash, in order to further minimize disruption to both people and animals.

All questionnaire data is anonymous, with no identifying information collected through the course of the study. Camera traps were placed and aimed to maximize photo-capture of non-human animals, and to minimize the capture of any people, especially site stakeholders and participants. Both the completed questionnaires and the photographs from camera traps were stored securely, in either physical copy or a noninternet connected backup drive, further ensuring privacy. Additionally, stakeholders were informed of the operation of camera traps, the use of the photographs/data collected from the devices, and mammal photographs/data were shared with the participants after the study concluded, (Sharma et al., 2020). Photographs with people in frame were not shared and were destroyed on conclusion of the research.

Ethics approval for this study was for the period of 08/18/2022-08/18/2023, granted by the Human Participants Review Committee of the Office of Research Ethics in York University, with the certificate number: STU 2022-090. As there would be no direct interaction between the researcher and any animals throughout the course of research, further review of the research proposal by the Animal Care Committee was deemed unnecessary.

4. Results

4.1 Ecological Results

Over a total of two-hundred sixty-five camera days, 212,485 photographs were captured. Of these, 51,156 were captured at Maloca Community Garden, while 161,329 were captured at FreshCity Urban Farms in Downsview Park. The inflated number of photographs from FCUFs was due to an increased amount of wind-based plant movement on site, and placement errors leading to a few datasets over 10,000 photographs. Four datasets with over 7,000 photographs were rapidly reviewed due to the unlikelihood of mammals appearing in photographs. Example photographs from each of the four datasets are available in Appendix B. Two hundred fifty-seven camera days were processed across both sites, with all camera days processed at Maloca CG and ninety-three percent processed at FreshCity UFs. Out of all the processed photographs, 3,877 or six percent contained an identifiable mammal in frame. Exact numbers and percentages are presented in Table 2.

Table 2: Breakdown of camera days and photographs per site, with amount and percentage processed and reviewed.

Site:	Maloca Community Garden	FreshCity Urban Farms
Camera Days (C.D.)	149	116
Camera Days Processed	149	108
Percentage C.D. Processed	100%	93.1%
Number of Photos	51,156	161,329
Photos Processed	51,156	125,892
Percentage Photos Processed	100%	78%
Camera Days Reviewed	0	8
Percentage C.D. Reviewed	0%	6.9%
Number of Photos Reviewed	0	35,437
Percentage Photos Reviewed	0	22%
Camera Setups	19	19
Repeated Locations/Setups	1	1
Mammal Photos	2699	1282
Percentage Mammal Photos (Processed only)	5.3%	1%

4.1.1 Biodiversity

Assessing the mammalian species diversity of each site exemplifies which species are inclined to risk human interaction and disruption for access to consistent, expectable sources of food and shelter. Fourteen individual species were identified by independent events documented through photographs, eight of which were found across both sites, with six being unique at either site. Five species were photographed only at Maloca Community Garden, with one species photographed only at FreshCity Urban Farms.

Maloca C.G. had thirteen mammalian species documented, and a higher species diversity than FreshCity UFs, which had eight documented mammalian species. Thus, MCG had a higher Shannon index score than FCUFs, with both more species and generally more sightings per species. The Shannon index score for Maloca C.G. is 2.089, while the score for FreshCity UFs is 1.231. The difference can be attributed to three things: the geographic context of the two sites, the difference in human visitation between sites, and the recent establishment of FCUFs at their site. MCG is unfenced, and nestled within a fifteen kilometer stretch of the Black Creek nature area, making it extremely accessible for any species that live in or travel through the area. FCUFs moved to their current site in Downsview Park in 2021. Their original location was more centrally located within the park, and was farmed by a different organisation in 2022. The site was significantly landscaped before the move. The landscape changes would have impacted movement and population in local species, likely leading to a rebounding population of rodents and recolonization by larger mammals during the study period in 2022.

One of the more interesting findings of this study is the *absence* of a usual urban species, red fox (*Vulpes vulpes*), it was never photographed, nor documented through pawprints, scat or sightings. The exclusion of red fox from both study sites could be due to the presence of coyotes (*Canis latrans*) at both Maloca C.G. and FreshCity UFs, differences in preferred habitats and diets between the two species, or differences in ranges, (Mueller et al., 2018). Whatever the cause, it is intriguing that one of the most studied urban mammals did not make a single appearance in this study.[3]

The Eastern grey squirrel (*Sciurus carolinensis*) was the most documented species at Maloca Community Garden, followed by domestic animals. Eastern grey squirrel is one of the most urban-adapted mammal species in Eastern North America, and are in every urban landscape east of the Rockies.[4] In Toronto, there are two main coat colours, grey and black, black-coated squirrels were particularly easy to pick out and identify. Domestic animals, dogs (*Canis lupus familiaris*) and cats (*Felis catus*) were identified a combined one-hundred thirty-three times, though for both species, photographs were often clearly the same individuals on daily walks or nightly roaming. Striped skunk (*Mephitis mephitis*), Virginia opossum (*Didelphis virginiana*), groundhog (*Marmota monax*), Norway rats (*Rattus norvegicus*), and mice (*Peromyscus maniculatus/Mus musculus*), were all most commonly photographed in close proximity to the garden shed in MCG. Raccoons (*Procyon lotor*), Eastern cottontails (*Sylvilagus floridanus*), white-tailed deer (*Odocoileus virginianus*), and coyote (*Canis latrans*), were often photographed on paths running between garden plots in MCG, or the path running through it to the Black Creek. The most surprising species documented in this study was the American mink (*Neogale/Neovision vison*). American mink are not often documented in urban areas[5], in this case, the species presence is likely supported by the nearby Black Creek and Strong Pond on York University campus. Below, Table 3 organizes the species identified in photographs captured at Maloca Community Garden, from highest to lowest incidence of appearance.

---

[3] A review of global research trends found that red foxes were the second most studied urban carnivore from 2010-2020, (Collins, M. K., Magle, S. B., & Gallo, T. (2021). Global trends in urban wildlife ecology and conservation. *Biological conservation*, *261*, 109236. https://doi.org/10.1016/j.biocon.2021.109236).

[4] Koprowski, J. L., Munroe, K. E., & Edelman, A. J. (2016). Gray not grey: Ecology of Sciurus carolinensis in their native range in North America. *The Grey Squirrel: ecology & management of an invasive species in Europe. Woodbridge, Suffolk UK: European Squirrel Initiative*, 1-18.

[5] The most recent documented American mink (*Neogale/Neovision vision*) found by the author was a single incidence in Manhattan, in a large-scale study of urban landscape effects on mammal species richness, diversity & evenness, (Bradfield, A. A., Nagy, C. M., Weckel, M., Lahti, D. C., & Habig, B. (2022). Predictors of Mammalian Diversity in the New York Metropolitan Area. *Frontiers in Ecology and Evolution*, *10*, 903211.)

Table 3: Species & incidence rate, with 30-minute interval for Maloca Community Garden.

Species	**Count**
Sciurus carolinensis, Eastern Grey Squirrel, grey or black	137
Canis lupus familiaris, Domestic Dog	81
Felis catus, Domestic Cat, four-five individuals	52
Procyon lotor, Raccoon	37
Mephitis mephitis, Striped Skunk	37
Didelphis virginiana, Virginia Opossum	23
Marmota monax, Woodchuck/Groundhog	18
Rattus norvegicus, Norway Rat	17
Sylvilagus floridanus, Eastern Cottontail	17
Odocoileus virginianus, White-tailed Deer	15
Neogale/Neovision vison, American Mink	4
Peromyscus maniculatus/Mus musculus, Deer or House Mouse	3
Canis Latrans, Coyote	2

FreshCity Urban Farms had a lower overall diversity of species, but a much higher incidence of rats and mice photo captures. Rats were most often photographed overnight in two of the composts on site, Ubuntu Community Collective (UCC) and Toronto Well-Watered Garden (TWWG), a demonstration garden in the corner of Zawadi Farm. Both farms manage compost on their sections of FreshCity UFs, with each sustaining at least one rat nest. Similarly, the vast majority of mouse photo captures were taken overnight, inside the greenhouses at FCUFs. Coyotes were most often documented on the move, with very short bursts of photographs, investigating the TWWG compost and FCUFs crop coverings. Eastern cottontails were primarily documented in the early morning or overnight, often in short bursts in growing plots. A striped skunk also investigated the compost and crops of TWWG within FCUFs, but was not documented moving farther into the site. Two domestic dogs were captured on walks on the perimeter path of FCUFs, which is quite low in comparison to MCG. A vole appeared the greenhouse of FCUFs, in the early morning, possibly burrowing or taking advantage of the available crops. The only raccoon documented onsite moved past the camera setup at UCC's compost, but did not investigate it. Following, Table 4 outlines the identified species and their incidence of appearance at FreshCity Urban Farms, from most to least.

Table 4: Species & incidence with 30-minute interval for FreshCity Urban Farms, Downsview Park.

Species	Count
Rattus norvegicus, Norway Rat	84
Peromyscus maniculatus/Mus musculus, Deer or House Mouse	71
Canis latrans, Coyote	14
Sylvilagus floridanus, Eastern Cottontail	8
Mephitis mephitis, Striped Skunk	3
Canis lupus familiaris, Domestic Dog	2
Microtus pennsylvanicus, Meadow Vole	1
Procyon lotor, Raccoon	1

Most of these species are well-known urban-adapters and urban-exploiters.[6] Nearly every urban resident has seen at least one of these species when going through their daily life, and definitely in a park, garden, or greenspace in the city. The species documented in this research are well-known to urban biodiversity studies, but this is their first documentation in urban agriculture specifically. The richness of mammal species in Maloca Community Garden and FreshCity Urban Farms informs their expected behaviours, and enlightens the reactions of human participants.

4.1.2 Behaviour

In order to establish the behaviour of mammals at Maloca Community Garden and FreshCity Urban Farms, all processed photographs with a mammal present were assessed for indications of mammal behaviour on site. The photographs used for determining behaviour were time-series photographs, and any photograph with a mammal in-frame was evaluated for produce indicating foraging and active denning in a

[6] Blair, R. B. (1996). Land use and avian species diversity along an urban gradient. *Ecological applications*, *6*(2), 506-519.

photo-series. Out of a total of 177,048 processed photographs, mammals were present in 3,981 (2.3%) photographs across both sites. Further, of the photographs with mammals in frame, 1,290 photographs (0.73%) exhibited clear mammal behaviour which were determined as either relating to foraging or denning. Photographs displaying eating/gathering of garden produce or active hunting were considered active foraging behaviours, e.g., Eastern grey squirrel eating a tomato grown by a gardener or farmer. Photographs showing active burrowing or repeated entrance/exit of an existing den were deemed denning behaviours, e.g., striped skunk (*Mephitis mephitis*) further dug out an existing burrow underneath a shed. Surprisingly, more photographs exhibited denning than foraging behaviour. The increase in denning photographs is particularly attributable to the behaviour of striped skunk and groundhog at Maloca CG, and rats at FreshCity UFs. These mammals, most likely one or a few individuals, moving in and out of the same den site repeatedly outperformed their own and other species that were documented foraging. The species most often documented foraging comes as no surprise to anyone who has grown food in an urban setting, the Eastern grey squirrel, at MCG. Following closely, rats at FCUFs heavily foraged the compost of Ubuntu Community Collective and Toronto Well-Watered Garden.

Maloca Community Garden had a very active wildlife community within the site, with many species foraging and denning on site. Documented foraging activity was evident both by the leftover half eaten produce, and in particular, the photographs of Eastern grey squirrels and white-tailed deer (*Odocoileus virginianus*) eating their fill. Both of these species made short work of fencing put up by gardeners, with Eastern grey squirrels, going through it and white-tailed deer going over it to get at the tomatoes, leafy greens and corn they sought. White-tailed deer were more damaging to infrastructure, sometimes bending fencing or fenceposts, or pulling fencing down in some cases as they went over. In some cases, unfenced plots were less damaged, as mammals would forage what they wanted, without having to contend with fencing. Though as can be seen below, they would forage more heavily on unfenced plots.

White-tailed deer *(Odocoileus virginiana)* foraging on produce (tomatoes & more) near the back of the garden shed at Maloca Community Garden.

Figure 1: Sample of photographs of white-tailed deer foraging behavior, MCG, 09/06/2022, 1:53-1:55AM

Eastern grey squirrels were particularly proficient at poaching produce, and were often documented foraging tomatoes grown in the garden, and the black walnuts from the trees in the garden and the nearby forested Black Creek area. Unsurprisingly, squirrels would eat the tomatoes immediately and store the walnuts for the winter. There was also a seasonality to the produce use, as the end of the tomatoes just about ran into the beginning of the black walnuts, but for there was a marked increase in photographs of black walnut foraging as autumn wore on. Figure 2 compiles a sampling of photographs documenting the foraging behavior of squirrels, tomatoes, black walnuts and other produce, as well as their fence-climbing.

Eastern grey squirrels (Sciurus carolinensis) were undetered by fences or other obstacles from foraging produce or storing walnuts in garden plots.

Figure 2: Sample of photographs of the foraging of Eastern grey squirrels, MCG, September-October, 2022.

Some of the most interesting instances of foraging came from a domestic carnivore, cats, (*Felis catus*). At one point, one of the domestic cats seemed to have caught or was in the process of hunting something on site. Unfortunately, it was not photographed with its prey. There was also a documented case of foraging by one of the domestic cats, it was photographed rubbing and biting/nibbling on some cat mint that was in the garden. These cases illustrate that even domestic animals will take advantage of produce, and the animals attracted to it, if available.

Cat pawing at, nibbling and biting a cat mint/nip plant, even domestic mammals take advantage of garden resources.

Figure 3: Sample of photographs of the foraging of a domestic cat (Felis catus) on garden produce, MCG, 10/14/2022, 7:22-24PM.

Striped skunk was also photographed with produce from Maloca CG, mainly leafy plants deposited in the den. However, as striped skunks are primarily insectivores, this is likely bedding or caching for winter. Raccoons, opossum, groundhog, and Eastern cottontail were also photographed eating produce, but it was not always clear if they were also enjoying the tomatoes or if they were foraging fruit or compost from MCG instead. These four species were photographed foraging at night, obfuscating the identity of the produce they were eating. While the five other species documented on site were not also photographed foraging, it can be reasonably inferred that they were also taking advantage of the food source provided by produce or other mammals on site.

Denning behaviour documented at Maloca Community Garden centered around MCG's tool shed. In particular, a den site underneath the garden shed was visited by almost all of the species present on-site. However, the burrow seems to have only been truly inhabited by two to four species. The burrow appears to change ownership a few times from August to November. In September, the den is inhabited by a groundhog, seen for a period of a few days exiting and entering the den, and even sunning itself or napping just outside the entrance. This is one of the busiest times for the burrow, as an opossum, raccoons, cats, and the occasional dog investigate it as well. In the same week, an American mink appears, potentially from either the known burrow or another den within or underneath the same shed, but is not photographed re-entering the den. Rats, and mice are also photographed exiting and entering from a direction indicative of a different burrow or den, or possibly from within the shed itself. About a month and a half later, a striped skunk digs the known burrow out further and brings in plant material for nesting or caching. Photographs of species documented denning at MCG are below, specifically focusing on inhabitants, the American mink, and one of the most common 'investigator species'.

Striped Skunk (Mephitis mephitis) Denning

Groundhog (Marmota monax) Denning

Opossum (Didelphis virginiana) Denning

American Mink (Neogale/Neovision vision) exits, but never re-enters

Investigator Species: Raccoon (Procyon lotor)

Figure 4: Selection of photographs of the various species documented denning in or investigating the den underneath the garden shed, showing species in order of most documented, and including the most surprising species, MCG, September-November, 2022.

The burrow was also the site of one of the more interesting conflicts in this project. At one point during the striped skunk's occupation, it seems to be challenged for the den by an opossum. The striped skunk is seen in front of the den, tail up, and in a defensive pose, while the opossum has its mouth open and appears to be hissing or otherwise showing some aggression. This encounter was fascinating for the inter-species conflict that urban agriculture spaces fostered, in addition to the human-mammal conflict. This conflict is a clear indication of the value of such a protected and well-provisioned den site, especially with coyotes in the area and winter approaching. While it appeared that the striped skunk kept possession of the den, the opossum was often documented passing by and sniffing around, possibly to see if the resident had moved. Several photographs from this incident are included below, and are among the most fascinating in the research.

First, opossum (Didelphis virginiana) investigates and plants itself in front of the den, then the striped skunk (Mephitis mephitis) returns, going about its routine but keeps its tail up the whole time, and the opossum leaves.

Figure 5: A sampling of photographs out of the ninety-five documenting the attempted takeover the den underneath the shed, MCG, 11/02/2022, 2:23-2:39AM.

In addition to the change in possession and attempted takeover of the den, many other species came to investigate it. Throughout the study, opossum, Eastern cottontails, raccoons, cats, dogs, and Eastern grey squirrels were all photographed getting close to and sometimes sticking their noses into the den itself. The only two species documented on-site not photographed near the burrow were white-tailed deer and coyote, which could be justified by a lack of interest on the part of white-tailed deer and a difference in seasonality shown in the coyote's appearance on site after snow fall, not in late summer/early autumn when the majority of species were present.

In addition to foraging and denning on site, a few species appeared to only be transiting through the site. Unsurprisingly, dogs were the species that moved through the site most often, as their daily walks went through the site in order to reach the Black Creek natural area beyond the garden. Cats were also frequently transitional, likely roaming nightly through cat doors or open windows. In addition to domestic mammals, Eastern cottontails, and both the American mink and the coyote moved through the site, rather than appearing to den or hunt. That the coyote was never documented hunting is particularly intriguing, as the site was rich with Eastern cottontails, rats and raccoons, all of which appeared in around the same crepuscular and nocturnal time frame as the coyote. However, the difference in seasonality between the appearance of the coyote and other mammals could again be the cause for the lack in documented hunting behavior. These moments illustrate that the garden is not always a resource, but sometimes a transitional space.

The foraging and denning behaviours of mammals at Maloca Community Garden exemplify the importance and value of MCG for local mammals. Mammals are frequenting MCG for food, as there is a higher likelihood of edible plants, and several species are taking full advantage of garden infrastructure to live near their food sources. However, this foraging and denning were not the only behaviours documented, as some species seemed to only transit through or occupy the site for a few hours or days at most. Table 5 organises species present at MCG, with the number of photographs per species, and a categorization of photographs for behavioural analysis.

Table 5: Number of Photographs Captured per Species, with Number of Foraging and Denning photographs, Maloca Community Garden.

Species	Photographs	Foraging	Denning
Sciurus carolinensis, Eastern Grey Squirrel, grey or black	549	140	
Mephitis mephitis, Striped Skunk	511	115	146
Marmota monax, Woodchuck/Groundhog	472	1	142
Canis lupus familiaris, Domestic Dog	210		
Felis catus, Domestic Cat, four individuals	190	23	
Odocoileus virginianus, White-tailed Deer	176	147	
Didelphis virginiana, Opossum	157	1	35
Sylvilagus floridanus, Eastern Cottontail	157	11	
Rattus norvegicus, Norway Rat	154		18
Procyon lotor, Raccoon	98	15	
Neogale/Neovision vison, American Mink	17		
Peromyscus maniculatus/Mus musculus, Deer or House Mouse	6		5
Canis latrans, Coyote	2		

FreshCity Urban Farms had a less diverse wildlife community, but still had both foraging and denning behaviors observed on site. Interestingly, mice were the most often observed entering/exiting the FCUFs greenhouses, but rarely foraged directly within camera range. The greenhouses on site are used primarily to store produce harvested from all of the organizations at FCUFs that is not ready for delivery or sale, start seedlings, or extend the growing season. This created a veritable cornucopia of food options for mammals that can gain access. Leafy lettuces or kale, red tomatoes, purple eggplants, aromatic herbs, cabbage heads, all available for nibbling overnight when human disturbance is non-existent, without the danger of overnight predation by larger urban wildlife, such as Owls (Strigiformes), the ever-observant red-tailed hawk (*Buteo jamaicensis*) on site, coyotes, foxes, or even domestic cats. Throughout the two weeks of camera placement in the greenhouses, mice were entering and exiting through small niches between the compacted soil and the metal frame. However, mice were not the only species to take advantage of the greenhouses for foraging opportunities. An

Eastern cottontail ate some leafy greens in the greenhouse that were being stored or grown there, but were attractive either way. The cottontail may have squeezed through the two-four inch space between the bottom of the door and the soil underneath, as no damage was documented from tearing or burrowing at the time. This behaviour demonstrates that the greenhouse must have had a high-level of attractants in it, or that the cottontail knew predators were unlikely to follow. All photographed foraging in the greenhouses took place after dark, or at least after workers had all gone home/reduced their presence in the greenhouse.

Rabbit (Sylvilagus floridanus) foraging in the greenhouse overnight, 10/26/2022.

Mouse (Peromyscus maniculatus/Mus musculus) entering the greenhouse, 10/23/2022, 6:56AAM

Mouse (Peromyscus maniculatus/Mus musculus) entering the greenhouse, 10/23/2022, 10:34PM

Mouse (Peromyscus maniculatus/Mus musculus) entering opposite side, 10/27/2022, 6:37PM

Mouse (Peromyscus maniculatus/Mus musculus) entering, 10/24/2022, 1:32AM.

Figure 6: A selection of photographs showing the foraging of species in the greenhouses, FCUFs, 10/23-27, 2022.

In addition to these activities by mice, rats, and Eastern cottontails; coyotes were a relatively frequent visitor of FCUFs, with foraging behaviors of their own. Coyotes came to the site to hunt the mice, rats and other prey that lived or foraged there. This hunting was most evidenced by torn crop-covering, paw-prints on crop covers, in nearby mud and snow, and a few photographs. The photographs were predominantly of coyotes moving through the area, but some do depict hunting activity as well, with investigations of rat nest containing composts and pouncing after tearing open crop covers.

Coyotes (Canis latrans) were often photographed roaming around FCUFs several times, often near documented dens or crop covers.

Figure 7: A selection of coyote (Canis latrans) sniffing out prey and hunting, FCUFs, September-November, 2022.

Two compost heaps at FreshCity Urban Farms, on the plots of Ubuntu Community Collective (UCC) and Toronto Well-Watered Garden (TWWG) were documented as sites of both foraging and denning for Norway rats. The rats were generally photographed foraging in or around their nests. In one particularly interesting sequence, dragging a half-rotten tomato back to the Ubuntu CC's compost, eating it on the way. Furthermore, the rats had the only active denning behaviour at FreshCity UFs, and the most active denning in the project, making dens in both UCC's and TWWG's compost heap with repeated entering/exiting overnight to forage additional food. Any compost heap is good nesting habitat, as they are relatively undisturbed (compost heaps are often turned only once a week at most), warm (compost heaps can often top 40° C), and has food added to it consistently, if not almost constantly.[7] A compost heap within the bounds of an urban farm has an even larger availability of nearby food than a home compost, due to the increased production in the area and use of the heap. The ability to safely forage from within or very near to the den greatly increases the likelihood of reaching cover when predators appear, and makes meeting daily dietary needs less taxing. These factors make it a nearly ideal den site, especially for a mammal that can tolerate occasional to moderate disturbance. Coyotes were also documented investigating the compost at TWWG, due to the presence of rats, mice and other food.

Early morning, one of the rats (Rattus norvegicus) found a tomato, either in the compost or a neighboring field, and brought it back to its den, eating it on the way.

Figure 8: Selection of photographs from the instance of the UCC rat (Rattus norvegicus) moving & eating a tomato, FCUFs, 10/20/2022, 7:38-45AM, 10:40AM and 12:40PM.

[7] These facts are fairly common knowledge among composters, but are also mentioned and temperature is investigated in a 2005 Doctoral thesis, Sundberg, C. (2005). *Improving compost process efficiency by controlling aeration, temperature and pH*. Swedish University of Agricultural Sciences Uppsala.

While the species richness and number of photographs at FreshCity Urban Farms were lower, there were still interesting interactions between the site and the mammals that utilized and lived on it. Eastern cottontails, mice, and coyotes all making use of the site as a food source is unsurprising, but illustrates the utility of the site as part of a territory. Furthermore, the rats' dual-use compost heaps are particularly remarkable for the unexpected ingenuity of living in a rat-sized grocery store. Below, table 6 organizes species present at FCUFs by number of photographs, and further compares behavioural photographs.

Table 6: Number of Photographs Captured per Species, with Number of Foraging and Denning photographs, FreshCity Urban Farms.

Species	**Photographs**	**Foraging**	**Denning**
Rattus norvegicus, Norway Rat	702	97	395
Peromyscus maniculatus/Mus musculus, Deer or House Mouse	407	27	
Canis latrans, Coyote	111	4	
Sylvilagus floridanus, Eastern Cottontail	36	22	
Canis lupus familiaris, Domestic Dog	11		
Mephitis mephitis, Striped Skunk	9		
Procyon lotor, Raccoon	3		
Microtus pennsylvanicus, Meadow Vole	3		

The heavy utilisation of both of these urban agriculture sites by local mammal populations demonstrates the suitability of these spaces as habitat in an otherwise less-than-hospitable landscape. Interspecies interactions further prove the significance of agriculture spaces for urban wildlife. The habitat and food source(s) provided by urban agriculture are not only attractive to these species, but worth defending. Interspecies conflict over denning in Maloca Community Garden establishes the preciousness of urban agriculture to nearby wildlife, as habitat and food source. Additionally, the presence of Norway rats in two active composts (TWWG and UCC) at FreshCity Urban Farms demonstrates the dual-use of compost as foraging and denning site. Both of these instances indicate that urban agriculture allows for a level of territory or range contraction. These species do not have to range as widely to forage, and it is likely that many of the other species are also denning nearby. This compaction could have implications in the energy-budget needed by these mammals, as they are able to spend more time on other tasks, due to the availability of food on site.

This research on mammal behaviour in urban agriculture expands our knowledge of urban mammal behaviour, and the changes happening as species adapt to the cityscape. Conflicts between people and mammals, and inter-species conflicts are likely to increase in number and intensity as more habitat becomes urbanized and more mammals move into it. Understanding mammal behaviours, and changes to previously known behaviours, facilitates a greater ability to prepare and adapt to them in order to prevent conflict.

4.2 Social Results

Survey participation was lower than anticipated, and while trends are evident within the dataset, they cannot be held to be indicative beyond these two sites. In addition, there was not a comparable number of responses from both sites, as such responses were combined to demonstrate general trends. There were four respondents from Maloca Community Garden (MCG), and eleven from FreshCity Urban Farms (FCUFs), Downsview. All fifteen respondents spent more than an hour per visit. However, FCUFs had more consistent visitation by stakeholders, seven out of eleven respondents were there daily or more than twice per week. The increased rate of visitation is linked to the non-profit and commercial organizations on the site, as it is a place of employment for some, as opposed to MCG, as a shared gardening space. To follow are several graphs illustrating noteworthy trends among questionnaire responses.

Many previous studies have shown that stakeholders in urban agriculture projects build very positive emotional relationships with both others involved, their wider community, and their local ecosystem. Urban agriculture projects are places to connect and work with nature.[8] This is reflected in this project particularly through participants' responses to two questions, seven and eight. Question seven asked participants to assess the impact their urban agriculture site had on them, to which all participants responded positively, with three "Somewhat positive" and twelve "Very positive" responses. Participants were also mostly in agreement to a positively-enhanced experience of urban agriculture with the presence of mammals. Participants' experience of their urban agriculture setting was improved by the mammals that they saw or perceived as being there with them. These spaces foster connection not only to nature as sun, sky, plants, and soil, but also to more of the 'undesirable' aspects, like mud, storms, insects, and mammals that damage what we value. Below, Figure 9 compares responses to the question: 'How do mammals effect your experience of the urban farm/community garden?'; out of fifteen responses, the majority (ten; two 'Very', eight 'Somewhat') reported a positively-impacted experience of urban agriculture. Three participants were neutral to the presence of mammals on-site, and only two felt negatively affected by mammals.

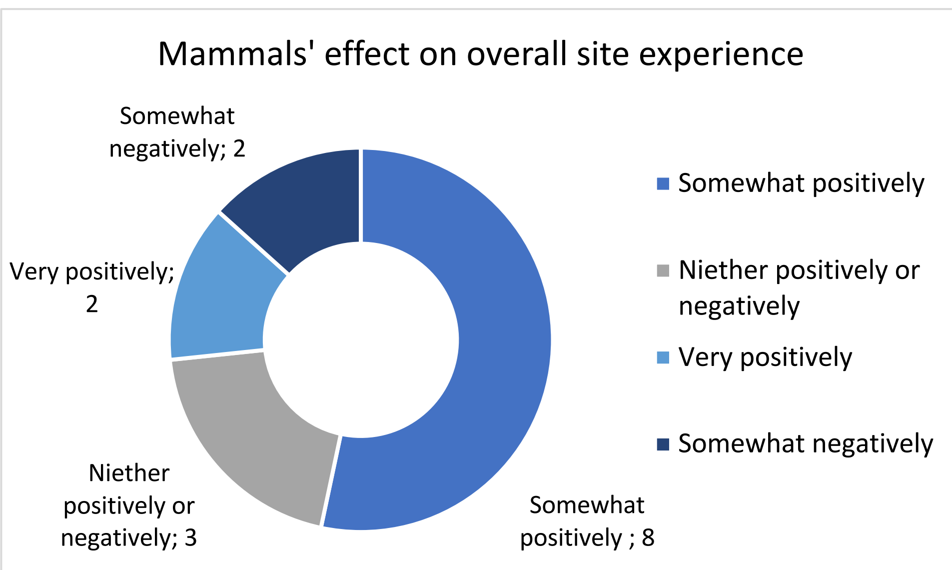


Figure 9: Responses to questionnaire question eight, 'How do mammals effect your experience of the urban farm/community garden?'

[8] Many studies have noted connection to environment as a strong component of urban agriculture, (Bailey, A., & Kingsley, J. (2020). Connections in the garden: opportunities for wellbeing. *Local Environment*, *25*(11-12), 907-920. , Egerer, M. H., Philpott, S. M., Bichier, P., Jha, S., Liere, H., & Lin, B. B. (2018). Gardener well-being along social and biophysical landscape gradients. *Sustainability*, *10*(1), 96.).

In contrast, as the scale and placement of mammals changed, so too did the responses of participants in both Maloca Community Garden and FreshCity Urban Farms. Predictably, mammals did not improve or enhance participants' experience of their own growing space, as they often damaged crops or infrastructure. It was mostly acceptable, even good for mammals to be in or around urban agriculture, but unacceptable for them to be in participants' growing space. Though, the negative reaction was not as drastic as might be expected, as none of the participants indicated that the presence of mammals in their growing space had a very negative impact, only a somewhat negative impact. Figure 10 represents participants' responses to question nine of the questionnaire: "How do mammals effect your experience of your growing plot?"; here the majority is almost exactly flipped to the negative (seven 'Somewhat negatively'), and lacks any responses in the 'Very negative' category. Even that response has only a small majority among participants, seemingly indicating a level of tolerance and acceptance of the presence of mammals. This follows a certain logic, as if they make one's time in the overall site better, they need to be tolerated at best in one's growing space.

However, following this relatively negative reaction to mammals in participants' own space, when responding to questions ten and eleven, 'What do mammals do to negatively affect you or your plot?'/ 'What is most eaten/destroyed?'; all respondents indicated that mammals eat vegetables, while four co-indicated that they also damaged infrastructure. Interestingly, most survey respondents from FreshCity Urban Farms did not acknowledge any frustration over nibbled produce, before or after picking, but instead expressed frustration over chewed irrigation lines and ripped crop coverings. Acknowledgment of the damage caused by mammals justifies the change in response from participants as the scale changed. When mammals begin to cause specific problems for specific people, in specific places, the mammals' behaviours, and even their mere presence became a problem.

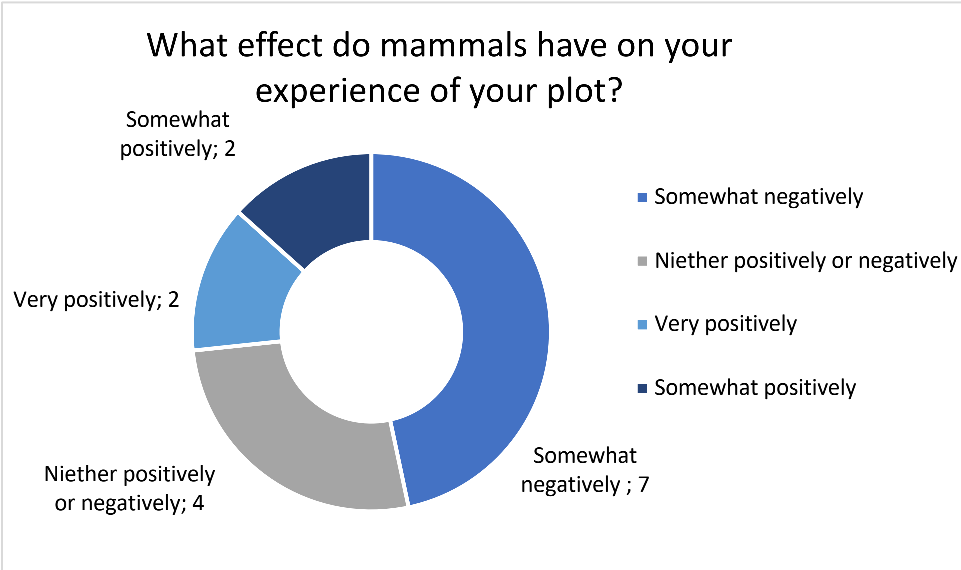


Figure 10: Responses to questionnaire question nine, 'How do mammals effect your experience of your growing plot?'

Questions ten through fourteen centred on investigating the negative and positive impacts of mammals noticed by participants

In line with the above findings, participants were split on whether mammals positively affected their growing plot or their time on site. As seen in Figure 11, by a slim majority, "Yes" overtook "No" in the responses to question thirteen: 'Do mammals positively affect your plot or time here [at site]?' The following question, one of several open-ended, question fourteen on the questionnaire attempted to challenge participants to think about the positive or potentially positive aspects of having mammals on-site; 'What do mammals do that positively affects your plot or time here [at site]?' This, especially placed after a yes/no question fostered interesting contrast between those who answered "Yes" and "No". Of the eight that viewed mammals positively, five specifically enjoyed seeing mammals, referring to them as cute/cool or feeling happiness on sight. Another three mentioned the local ecosystem, the ecosystem services provided by mammals (nutrient addition and weed elimination), or simple acceptance of the fact of their existence and instinct to survive. Of the six "No's," several mitigated their previous response, appreciating mammals in different contexts, or acknowledging ecosystem services provided by mammals, such as foraging compost/insects, and hunting mice. The other three did not provide any positive activities from mammals on site, stating that they eat food, damage infrastructure, and have no noticeable positive impact.

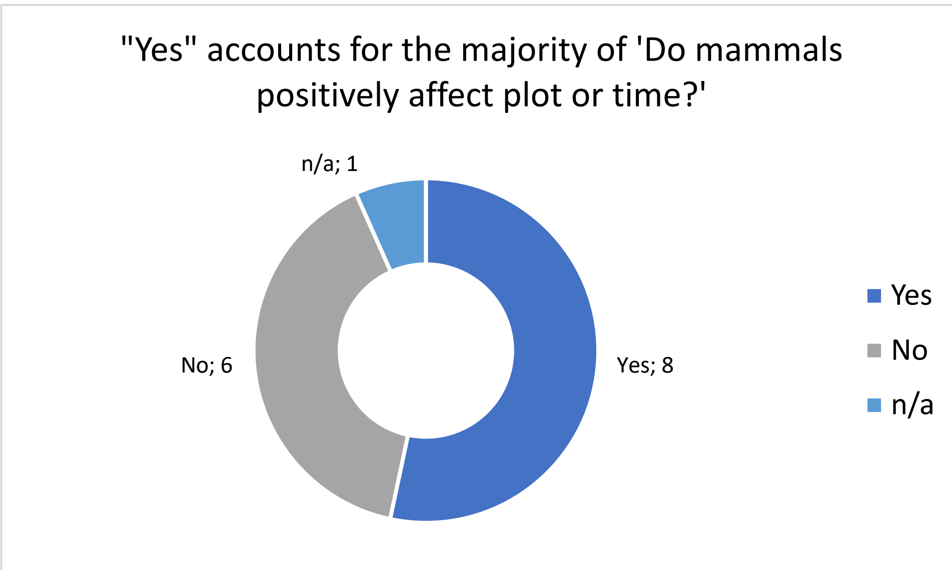


Figure 11: Responses to questionnaire question thirteen, 'Do mammals positively affect your plot or time here [at site]?'

Questions fifteen and sixteen probed participants perceptions of human-mammal interactions on-site. Fifteen was a simple three-option question, outlined in Figure 12, paired with open-ended sixteen, 'In your opinion, why are human-mammal interactions [on-site] positive or negative?' Interestingly, the perceptions of human-mammal interactions were overall positive, as indicated by ten participants. Nine of these ten participants elaborated in fairly unique ways, with some overlap and several answers with multiple reasons. Two revealed that they did not see or have interactions with mammals. Another four liked the aesthetics and predators mammals brought to the site, or of the mammals themselves, saying that they were cute, looked wild, and made the urban feel more rural[9]. Furthermore, two felt that interactions were positive from a more

[9] The feeling of bringing the rural to the urban, via nature within urban agriculture has been a long-standing goal of urban agriculture programs, traced back to the 1890s, as illustrated on page 22 of City Bountiful: A Century of

ecosystem, sharing with mammals' perspective, "they eat a small percentage of crops; let us know what tastes good." Finally, one participant was felt that interactions were positive, due to the strength of a barrier keeping their plants undisturbed. Only two participants perceived human-mammal interactions as negative, one recognized that they did not have interactions with mammals, and the other specified foraged and damaged produce as the cause of negative interactions. Two of the participants that made up the three neutral/both responses, similarly centered their perceptions around eaten produce, but also acknowledged their enjoyment of seeing mammals. However, the third neutral/both participant further hoped for an ecosystem integration with their site, to bring pests into balance and because they loved seeing animals.

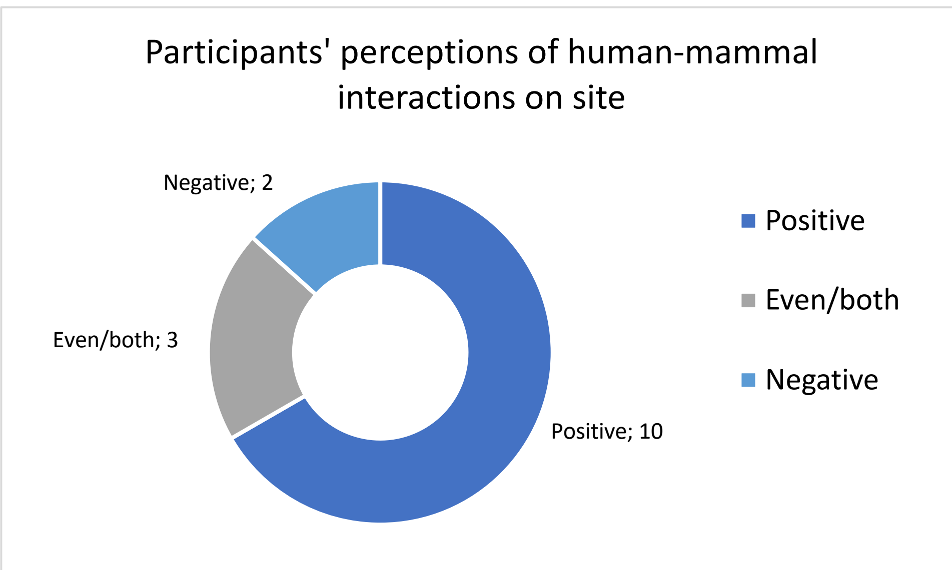


Figure 12: Responses to questionnaire question fifteen, 'Are human-animal interactions here [at site] mostly positive or negative?'

Question seventeen sought to check the corroboration between species stakeholders reported on-site and species documented by camera traps. This revealed overlaps that occurred, thus giving opportunity for human-mammal interaction, or those that did not occur, showcasing diurnal, nocturnal and crepuscular behaviour patterns, and avoidance

---

Community Gardening in America, Lawson, L. J. (2005). *City bountiful: A century of community gardening in America*. Univ of California Press.

behaviours by certain species. Participants with Maloca Community Garden were unaware of the presence of five species, groundhog, American mink, striped skunk, rats, and opossum. Groundhog was almost entirely diurnal, with many daytime photographs, often lounging outside the den site, but did seem to disappear into the burrow just before a domestic dog was photographed investigating it, and just before shoes get photographed too. This marks the groundhog as an interaction avoider – especially as it is making sure to avoid any species coming near its den. While the American mink was documented a few times, it was also primarily during the day, with some crepuscular activity as well. There were no clear indications of avoidance or specifically nocturnal activity patterns, but it could be assumed that the American mink would also avoid people and dogs. Striped skunk was primarily nocturnal, but was documented burrowing and foraging for cached foliage during the day. There were also some photographs that appeared to show avoidance, with the disappearance of the striped skunk just before the appearance of a dog's nose or person's shoe. Rats displayed entirely nocturnal behaviour, only appearing long after the sun had set. The final species not reported by participants at MCG was the opossum, which also exhibited exclusively nocturnal behaviour. Thus, it would be difficult for human-opossum sightings or interactions to ever occur.

The participants from FreshCity Urban Farms reported all but one of the species documented by camera traps, one of the same that MCG was also unaware of. They did not report seeing any striped skunks. This discrepancy is understandable, as the striped skunks were documented overnight each time, and would be unlikely to leave any evidence of its presence beyond a pawprint, only in snowy or very muddy conditions.

The final questions presented to participants sought to assess how problem mammals are currently dealt with, and examine potential strategies presented by participants to foster positive human-mammal interactions, instead of only seeking to end negative interactions. They also attempted to assess which species were the most positively- and negatively-impactful. Small rodents (Rodentia) were the species' that had the most negative impact, while rabbits, squirrels, coyotes, and raccoons were also mentioned. While most participants were not sure about a species they deemed the most positive, others mentioned coyotes, hawks/birds (Accipitriformes), raccoons, snakes (Serpentes) and interestingly, rodents for attracting those same predators to the space. Many of the participants had very hands-off strategies for dealing with pest mammals, like using a planting strategy, taking loss into account, and counting on predators to take care of some. Some did use more involved means of dealing with the mammals, particularly small rodents (Rodentia). These strategies revolved around traps and physical barriers like crop covers, fences or keeping things in containers/stored. Site administration also outlined similar tactics, with the ecosystem services of local predators being central, and less emotionally conflicting than traps. Traps are a necessity, especially for indoor/greenhouse spaces, as predators cannot get inside, but smaller mammals definitely can. One potential solution mentioned by two respondents was getting a farm cat for the next growing season. This would be quite an interesting solution, but may be very complicated in reality.

In terms of increasing positive human-*animal* interactions, not many had answers or ideas. Two more colorful responses suggested training animals to be pets or friendly with those on site. Meanwhile, more practical answers proposed more education on the local ecosystem, for stakeholders and visitors, as well as easily accessible information about the wider ecological landscape context around the urban agriculture site. Another proposal suggested increasing pollinator and predator-insect host plants, secured compost, decreasing potential rodent hiding places, increasing access/attraction for predator species, and more.

The fifteen participants of this study help to illuminate the human side of the human-mammal relationship in urban agriculture. Clearly, it is varied, evolving, and seems to be malleable in many ways. It is also driven almost entirely by only the mammals people are directly aware of, those that are seen, or leave evidence of their presence behind. It is understandable, but it leaves the relationship people may have had with the species unknown to them uninvestigated.

This study builds on previous research showing that both community gardens and urban farms contribute to a healthier, enriched human community, and more sustainable cityscape. Through questionnaire responses, participants demonstrated their desire for an ecologically sound agriculture/park landscape, as well as a remarkable acceptance and even some appreciation for the mammals living in that landscape. Particularly, the acknowledgment of the ecosystem services mammals provided is in-line with previous studies findings around collapsing nature-society dualism, improved environmental understanding and connection to nature for urban agriculture stakeholders. Additionally, this research expands these understandings and connections beyond the concepts of "nature," and "environment/ecosystem," to ground them in specific relationships to mammal species and the interactions, direct and indirect that growers have with them. This expansion demonstrates that not only are growers' relationship and responses to "nature" improved, but also to the local mammalian species as they become familiar both with seeing and interacting with them.

4.3 GIS & Geo-location

Geolocation data collected throughout the research is presented in five maps; one exhibiting the sites' proximity to each other and local greenspace, and two maps per site, one each presenting camera locations and one each displaying the locations of any tracks or scat on or in proximity to the site. The locations of paw prints and scat were documented during the biodiversity surveys, and were included to show proximity and movements nearby and within the sites that was not documented by camera traps. Camera placement was limited by permission from the gardeners at Maloca Community Garden, and farmers at FreshCity Urban Farms, as the likelihood of non-target photo capture of them and anyone working with them greatly increased with the placement of a camera in their garden plot or farm area. Thus, some areas of both FreshCity UFs and

Maloca CG were inaccessible. Camera placements on the maps are not differentiated with the placement date, as cameras were moved week to week, with two cameras per site, per week, thus over-complicating geographic visualization.

Maloca Community Garden and FreshCity Urban Farms have relational proximity to each other, which makes them comparable for wildlife research. Both sites have some proximity to Black Creek and the greenspace that borders it. The parkland that MCG is placed in has little to no discernable difference from that of the Black Creek green corridor, making it much more accessible for wildlife moving through or living in the corridor. Thus, the increased diversity of the wildlife community in MCG can be understood through both the attractants of crops/produce and garden shed, and its proximity to the Black Creek natural area. Maloca CG is also significantly smaller than FreshCity UFs, thus while possible camera sites were decreased, the likelihood of target photo captures increased, due to a smaller area of necessary coverage.

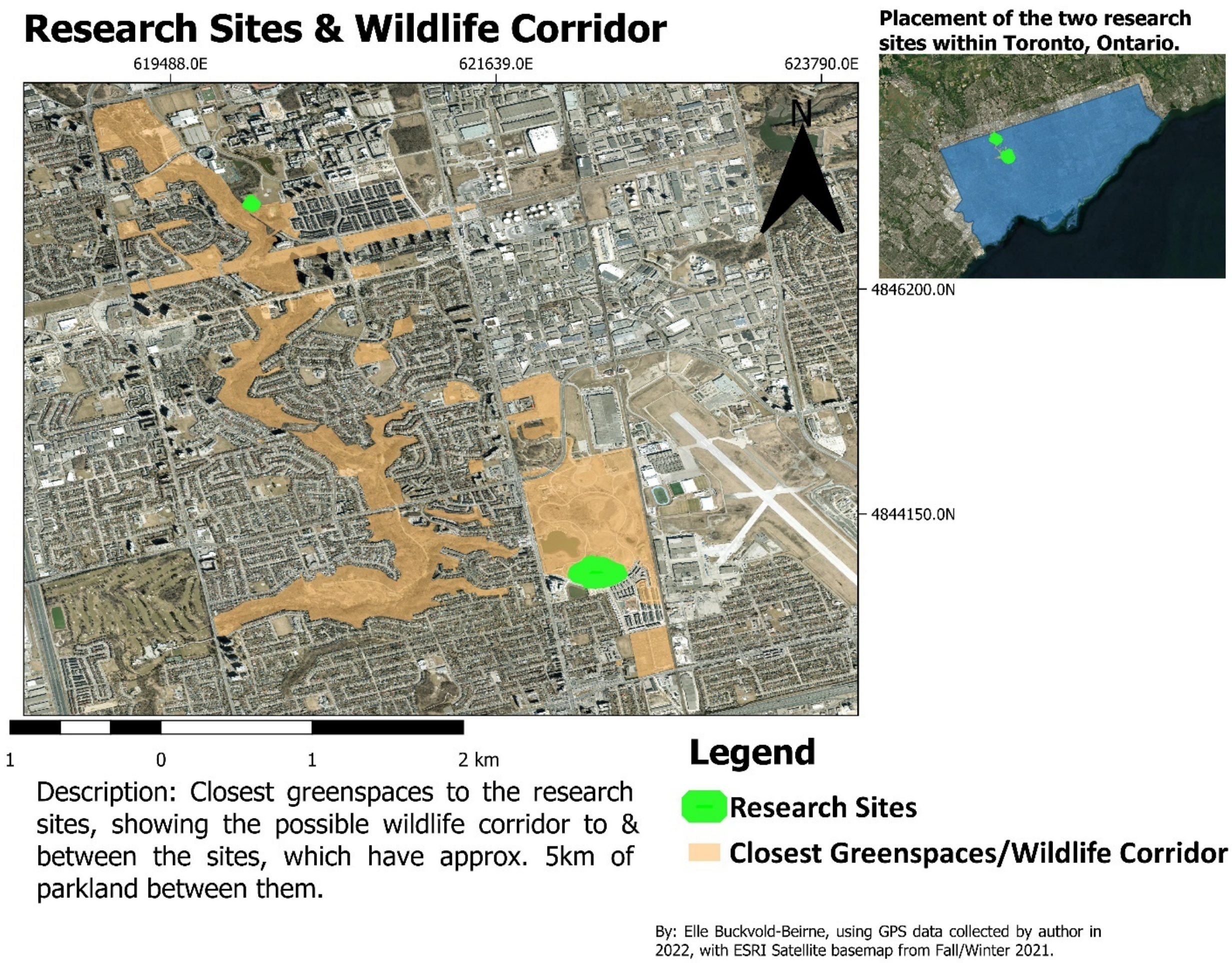


Figure 13: Map illustrating the closest greenspaces to and between the sites, with both research sites highlighted in bright green, this showcases the scale of urban landscape that wildlife would need to traverse to move between these two sites.

Maloca Community Garden and FreshCity Urban Farms are approximately five kilometers apart, with the possibility of wildlife traveling between them via the Black Creek natural area, as illustrated in Figure 13 above. Travel is unlikely for the majority of mammals documented in MCG and FCUFs, as they would have had to traverse a residential area and cross Keele Street into an area of Downsview Park with very little tree cover. With the exception of coyotes and white-tailed deer, it is very unlikely any of the mammals captured by cameras were moving between sites. Even those species are unlikely to regularly traverse the urban landscape to move between these sites. White-tailed deer at Maloca Community Garden would be much more likely to continue roughly a kilometer north through the Black Creek natural area to the Black Creek Community Farm than move five kilometers south to cross Keele Street.

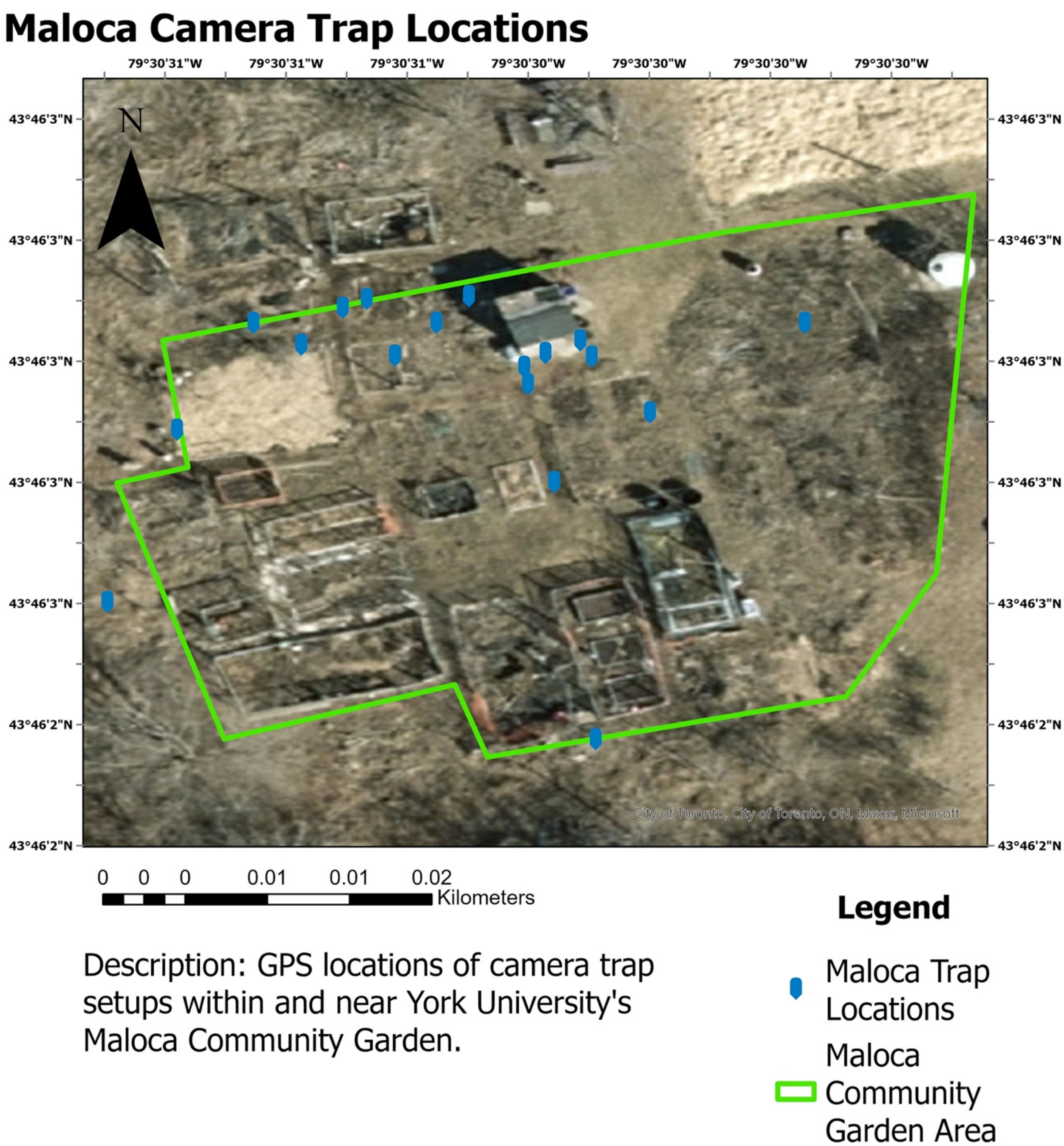


Figure 14: Map of Camera locations at Maloca Community Garden, including rough outline of garden area. Satellite image is from 2021, but the location of plots and shed relatively unchanged for 2022 research.

Maloca Community Garden has an area of 0.02 hectares, with mostly individual or family growing plots, managed with shared tools and some shared seeds or seedlings, but mostly on an individual or family basis, with little overlap in visitation time or growing style. Most of the camera placements shown above are on the north side of MCG, many of the camera placements were set up on trees, student-plot fencing, or communal infrastructure, such as the garden table on the back of the garden shed. Many of these placements faced the main path through the garden, which fostered an excellent understanding of the shared-use of the path, from gardeners, dog-walkers, and mammal visitor-residents. These placements are also due, in part, to the permissions given by gardeners on the northern side of the garden. Placements around the perimeter of the garden documented the presence, through entry and exit, of many species, but were not always well placed to document behavior.

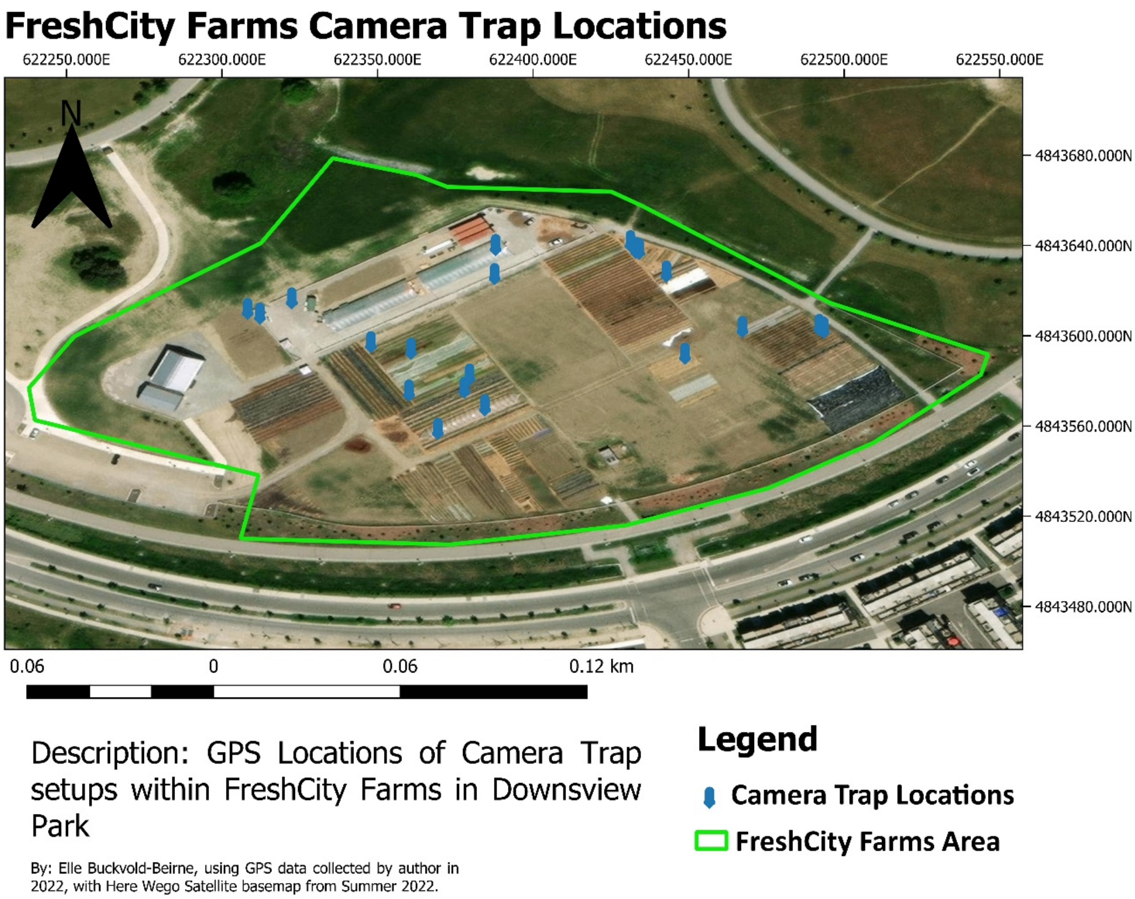


Figure 15: Map of Camera Locations at FreshCity Farms, including rough outline of farm site. Satellite image from 2022, showing greenhouses & plot divisions from study period.

FreshCity Urban Farms, a 2.02-hectare site, is a much bigger site than Maloca Community Garden, a 0.02-hectare site. Thus, even with the same limitation of stakeholder permissions, these is a lot of space to change camera placement, setup and view. Two placements were set up inside the main produce storage greenhouse, capturing mice and a vole (*Microtus pennsylvanicus*) entering/exiting, presumably to forage. Eastern cottontail was also documented inside the greenhouse, eating produce it had found on the floor. The rats' compost heap at Ubuntu Community Collective's field is the Eastern-most point.

One of the most generative setups was a two-camera setup with the lines of sight for one camera intersecting the other. This setup in Zawadi Farm's Toronto Well-Watered Garden (TWWG), depicted by two points near the north-eastern border of FCUFs, captured photos of many of the more elusive species on site. This setup documented coyotes on site, sniffing around the compost heap, as well as rats living in the heap, and striped skunk foraging near the edges of FCUFs. The striped skunk was documented at FCUFs by no other camera for the duration of research.

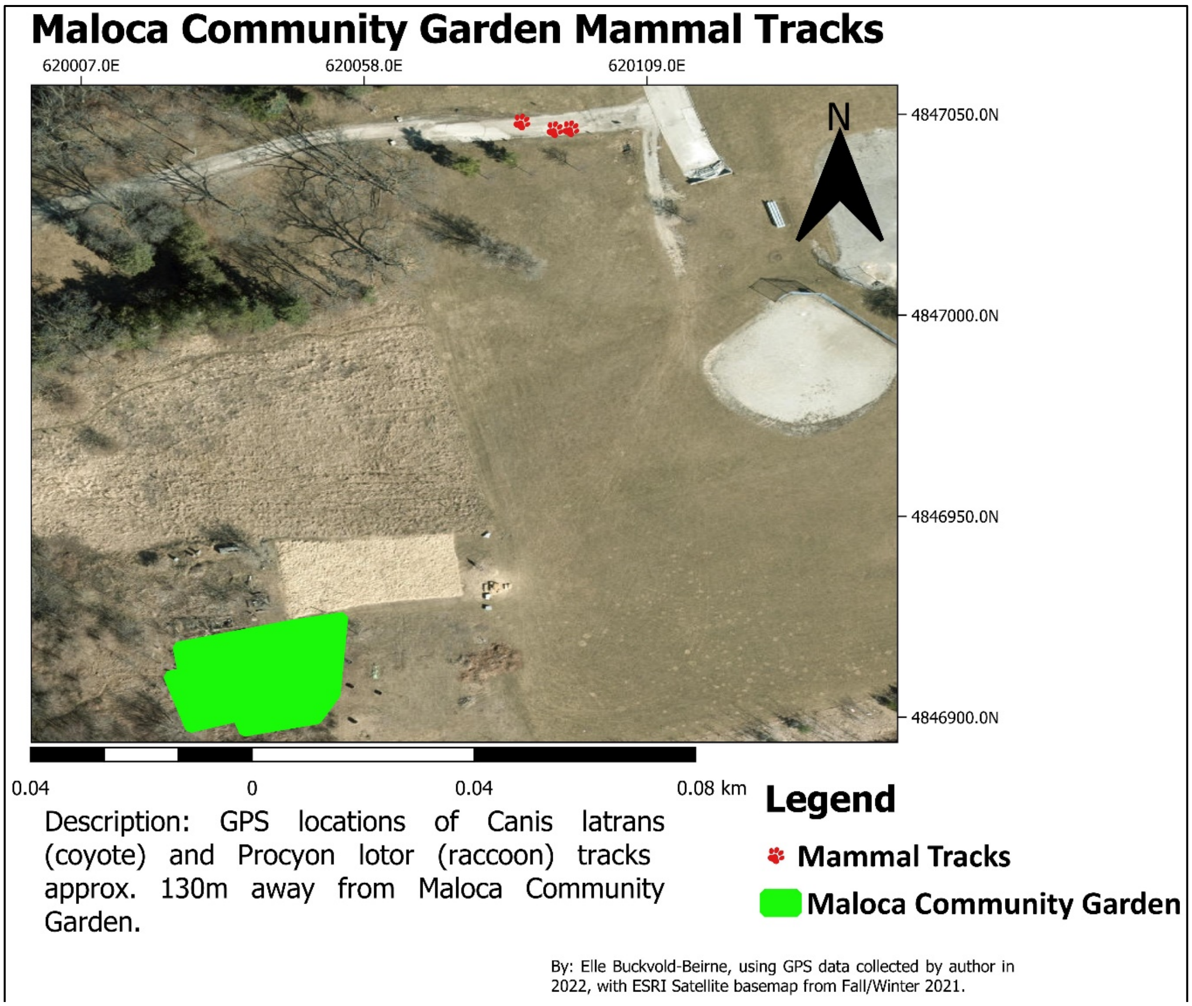


Figure 16: Map of paw print locations near Maloca Community Garden, two coyote prints and a raccoon print were documented.

While walking near the Maloca Community Garden site, a muddy area next to a small road held pawprints for two species, coyotes and raccoons. To date when the prints were found, only raccoons had been documented on site, and only in the final camera setup on site was a single shot of a coyote moving through MCG captured. During a post-research period visit of the site with fresh snow, more coyote tracks were found, with a clear trail running through the site to the other side of the road visible on the map, and beyond. What appeared to be striped skunk tracks and burrowing were also documented around and entering/exiting the den underneath the garden shed.

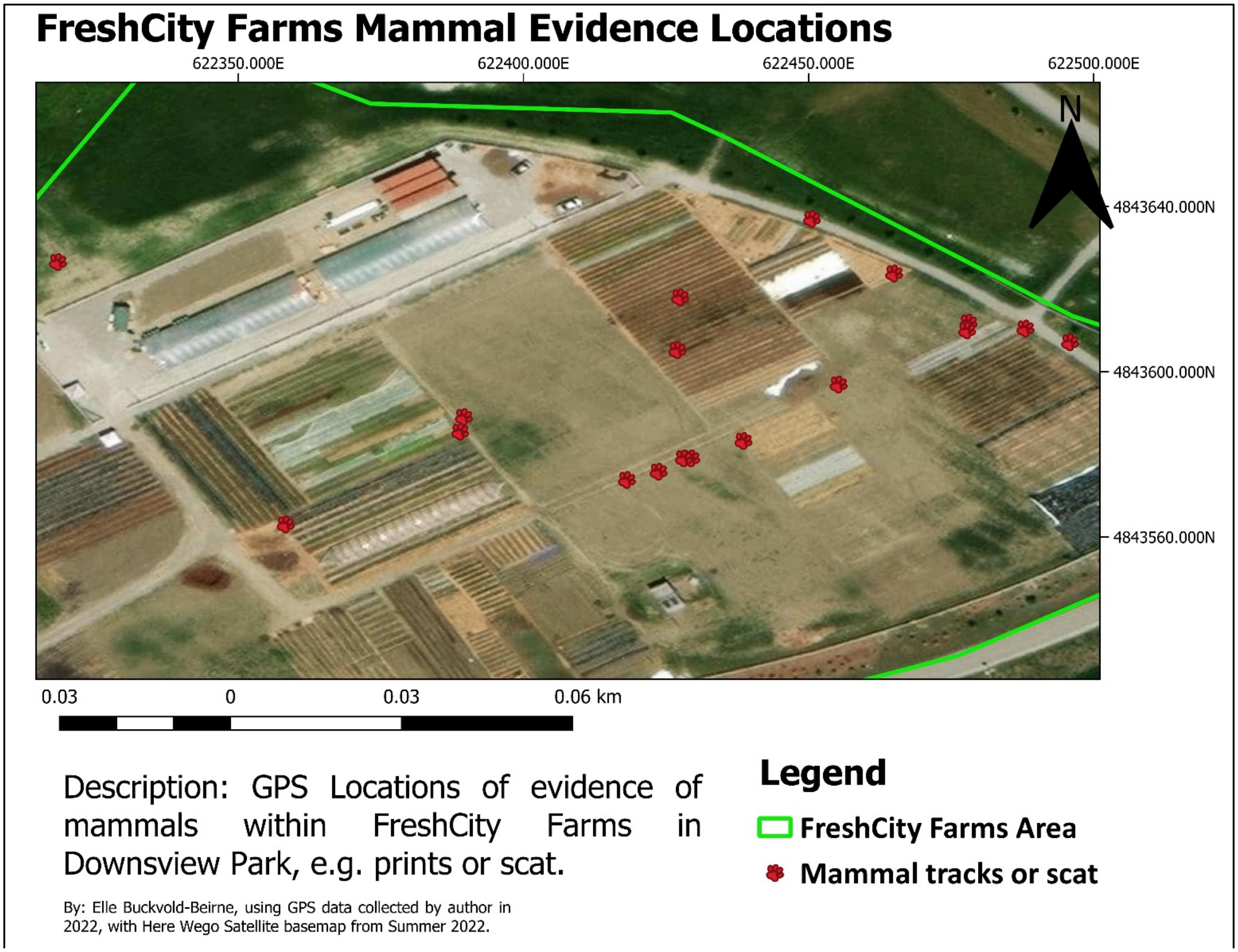


Figure 17: Map displaying locations of mammal evidence, both scat and pawprints at FreshCity Farms, all clearly identifiable as coyote prints and scat.

The only discernable tracks and scat found at FreshCity Urban Farms was that of coyotes, mainly in FreshCity Farm's own field, on crop-covers, or along the less used (by people) middle path between organizations' fields. The tracks were best documented in the last weeks of research, with muddier and snowier conditions. Tracks were also corroborated by photographs, and did pass by both matrix set ups, with one matrix setup successfully photographing coyote hunting behaviour at or near the position of the tracks within one field. The scat was found along the path as well, and was noted as not belonging to a dog on the presence of quite a bit of fur, appearing mostly to be rabbit (Leporidae) or rodent fur within the scat itself.

The relationship between growers and mammals in urban agriculture illustrates one of many possible landscapes of human-wildlife coexistence, especially within chaotic cityscapes. The landscape surrounding urban agriculture is often unwelcoming, if not directly hostile toward many species, though some persist anyway. As seen in the maps above, mammals are moving within and around urban agriculture, as well as foraging and living in it. This research exemplifies that urban agriculture offers oases to the concrete and glass matrix, both for us and for urban mammal species.

5. Discussion

This thesis works to develop a foundational understanding of the relationship between people and mammals in urban agriculture spaces through the examination of the positive and negative interactions and conflicts that develop between the growers and mammals that work, visit and live in community gardens and urban farms. The research develops this understanding by addressing three central questions: 1) What mammal species are detected in urban agriculture spaces? 2) What behaviours are they exhibiting while there? 3) What is the reaction of growers to mammal species in urban agriculture? These questions intertwine to develop a foundation for the exploration of the relationship between growers and mammals in urban agriculture.

Out of a total of 3,981 mammal photographs, fourteen mammal species were identified across both sites. Eight species were detected at both sites, with Maloca Community Garden having five exclusive species, and FreshCity Urban Farms having one. As such, the mammal detection data supports a finding of a greater species richness in Maloca Community Garden (2.089 Shannon Species Diversity Index) than FreshCity Urban Farms (1.231 Shannon Species Diversity Index).

Mammal behaviour at both sites centered on foraging and denning. The majority of species were documented foraging, particularly on crops, weeds and sometimes other mammals. Denning species were generally those that dig, and can tolerate a moderate-high level of human disturbance. There were also four species that were *not* documented foraging or denning, with three of those four seeming to only transit through the sites.

Additionally, the questionnaire response data indicate that growers' reactions to the mammals they interacted with – directly and indirectly – was much more nuanced than hypothesized. The data supports a potential relationship with an unexpected level of mammal-acceptance and acknowledgment of mammals' ecosystem services. Conflict was still central to this relationship, but coexistence was also critical to interactions and the human-mammal relationship overall.

5.1 Discussion of Ecological Results

5.1.1 Species Richness

The mammal species richness documented through this research is very much in line with urban mammal research overall. This result is expected, as urban landscapes expand and the climate continues to change, cities will house a larger portion of global biodiversity, and become important for conservation, (Faeth et al., 2011; Ives et al., 2016). This research shows that urban agriculture could be a key urban conservation space without being a traditional protected area, as both sites supported a number of mammal species while being multi-use urban greenspaces, (Fidino et al., 2021; Soanes & Lentini, 2019). Stakeholders were onsite weekly, if not daily, consistently working with the soil, harvesting crops, planting the next, watering, turning compost, or many other activities onsite. These sites were in near constant use by stakeholders, and were consistently visited by people walking by themselves or with their dogs. And yet, these sites had fourteen documented species visiting or living in them – further illustrating that conservation, especially urban conservation, is possible in spaces that are multi-use and have a high level of human visitation & disturbance.

This research also illustrates that urban agriculture is a significant habitat patch, similar to urban golf courses, parks and backyard gardens. Urban habitat patches have been found to be important supports for urban species, with both denning space and food resources, (Angold et al., 2006; Fidino et al., 2021; Gallo et al., 2017; Goddard et al., 2010; Sperling & Lortie, 2010). Backyard gardens are particularly significant for all species, as they can become spaces with abundant resources depending on the residents' management – flowers, vegetable plants, compost and other augmentations greatly impact both the species richness and biodiversity of these sites, (Hansen et al., 2020; Sperling & Lortie, 2010). Furthermore, increased habitat heterogeneity can have positive impacts on species' coexistence, but can also lead to niche-overlap or competition, if the habitat scale is too small or land-use changes, (Manlick et al., 2020). Both Maloca Community Garden and FreshCity Urban Farms had spatial heterogeneity, with different crops or different management by individuals and NGOs onsite, and both sites supported a number of species within relatively small spaces, at minimum in foraging, if not also denning spaces. While Maloca Community Garden is smaller than FreshCity Urban Farms, it had a higher level of species richness, this is most likely due to the size of the surrounding Black Creek natural area – as shown in section 4.4, Figure 13. Urban greenspaces with larger patch sizes have been observed with increased species richness, (Bradfield et al., 2022). Additionally, higher species richness was found in regions with both anthropogenic resources and increased greenspace in comparison to both rural and more urbanised regions, (Grade et al., 2022). Both of these sites qualify as areas with a combination of anthropogenic resources – crops, compost, sheds, greenhouses – within larger greenspaces, which impacts the species richness documented in this research. This combination most likely increases the species richness in both sites, particularly in comparison to greenspaces of similar scale that lack urban agriculture, and urban agriculture isolated from further green areas.

A study on the predictors of urban mammalian species evenness, richness, and diversity, which monitored more than thirty sites with over one-hundred and thirty cameras over the course of two to three years at each site, found fifteen mammal taxa *including* humans in greenspaces across New York City, (Bradfield et al., 2022). There were only two species documented in that study that was not documented in this study – chipmunk (*Tamias striatus*), and red fox (*Vulpes vulpes*). The fact that the findings of the research presented here are so similar another study – when the geographic, chronological and technologic scales are so vastly different demonstrates the likelihood of increased richness and diversity of species in urban agriculture sites.

Furthermore, based on the species and regularity of visitation/denning at both Maloca Community Garden and FreshCity Urban Farms and the above similarities, this author would propose urban agriculture as a biodiversity hotspot. Previous literature has acknowledged a need for increased study of such hotspots, and engagement with urban communities in the understanding and management of such places, (Rega-Brodsky et al., 2022). While the study does not produce a comparison of species richness in urban agriculture with surrounding areas or other greenspaces in a cityscape, it does document the species living in and interacting with urban agriculture.

5.1.2 Mammal Behaviour

As species live in and interact with the cityscape, their behaviour is changing. Literature around urban mammal behaviour often has a bias toward human-wildlife conflict, and focuses on species' management, (Ditchkoff et al., 2006; Fascione et al., 2004; Gehrt et al., 2010; Taylor et al., 2011). Species found in urban areas are those that can tolerate human disturbance, noise, and often make use of urban resources that can differ greatly from 'natural' habitat, (Chatelain & Szulkin, 2020; Łopucki et al., 2019). Behaviour changes have been documented in urban mammals when compared to their rural or 'natural habitat' counterparts. These changes often include diet, territory size, increased vigilance and nocturnal activity, (Ditchkoff et al., 2006; Lowry et al., 2013; Ritzel & Gallo, 2020). While several of these behaviours are not tested in this research, it is highly likely that the mammals photographed throughout the course of this research are presenting these changes. Territory compaction and increased nocturnal activity are particularly likely. The rats living in the compost at both Ubuntu Community Collective and Toronto Well-Watered Garden on FreshCity Urban Farms did leave their dens, but did not appear to be gone long, or go far in search of food. Additionally, nine species were documented with entirely or almost entirely nocturnal behaviour patterns: coyotes, opossums, rats, mice, eastern cottontails, striped skunks, raccoons and white-tailed deer.

The behavioural change most explicit in this research is dietary changes – while this is again not explicitly compared to species' natural habitats, the crop and produce foraging would not be considered a 'regular' diet for the species in this study. Striped skunks, squirrels, raccoons and opossums are omnivorous, but are not known to seek out tomatoes, kale or other crop foods in natural habitats. However, in this study, these species are documented repeatedly with produce – tomatoes were a favorite of squirrels, while raccoons raided compost and crops both. Foraging in urban agriculture leads to a much more specific, but potentially much wider diet for mammals than previously documented. The crops and produce available are going to be specifically selected by the growers in these spaces, due to their production, flavour, or other factors. However, these plants will range from heirloom varieties of native plants to new breeds and culturally significant imported crops. This range greatly changes the available forage for local mammals and likely increases the variety in their diet. Additionally, depending on the site, compost can range from only garden/farm waste to household compostable waste, which can include eggshells, orange/banana peels or other organics not naturally available to some species. Compost heaps were especially beneficial to rats at FCUFs, as they could both forage and den in the heaps. These places make excluding rats from FCUFs even more difficult, as compost is a tenant of organic farming, but is expensive and difficult to seal on that scale. The wide availability of habitat and foraging opportunities for rats in the urban landscape makes them one of the most prolific and difficult to control urban species, (Byers et al., 2019). Behavioural changes are a key part of urban survival, cityscapes are highly variable, changing habitats – with much higher disturbance, different food sources, and less available habitat.

5.2 Discussion of Social Results

Urban agriculture in some form has been a longstanding piece of the urban landscape, and has been utilised to 'solve' a plethora of issues – from food insecurity, crime, health and aesthetics, (Brault, 2010; Delshad, 2022; Draper & Freedman, 2010; Lin et al., 2015)

– since the 1890s, (Lawson, 2005). UA has a wealth of well-documented social and economic impacts. People involved in urban agriculture report improved fruit and vegetable intake and exercise, increased social and natural interactions, lower levels of anxiety and depression, (Alaimo, Beavers, et al., 2016; Beavers et al., 2020; Park et al., 2014; Poulsen et al., 2014; Soga et al., 2017). Economically, UA increases access to produce, increases home values and decreases household food costs, (Furness & Gallaher, 2018; Voicu & Been, 2008; Wang et al., 2014). These benefits are assumed to be present and experienced by the growers and stakeholders of Maloca Community Garden and FreshCity Urban Farms, and as such informed the framing of the questionnaire and some of the analysis of the results. One of the questions at the start of the questionnaire asked participants to rate the site's positive, neutral or negative impact(s) on them. Unsurprisingly, all participants expressed feeling a positive effect from urban agriculture.

The most relevant impacts of UA for this study are the environmental impacts. These impacts also range widely, including: city cooling, improving air quality, decreased rainwater runoff, and support for urban wildlife, (Anderson & Gough, 2022; Clarke & Jenerette, 2015; Clucas et al., 2018; Lin et al., 2015). UA research has documented that stakeholders' have improved environmental understanding and protection, and a stronger sense of connection with nature, in addition to the previously mentioned benefits and human community building, (Egerer et al., 2018; Hawkes & Acott, 2013; Hawkins et al., 2013; Holland, 2004; Travaline & Hunold, 2010). UA support for wildlife is the focus of this research. This is examined through the species richness and behaviour of mammals visiting, interacting with or living within the research sites, and through the reactions, conflicts, and coexistences stakeholders and growers had with those mammals. The findings of the questionnaire put forward to participants of this study are in line with previous findings of stakeholders' environmental understanding. Growers in both Maloca Community Garden and FreshCity Urban Farms demonstrated an awareness of ecosystem services and ecologic understanding in their reactions to mammals on site(s). Several participants acknowledged the services provided even by pest mammals and species they were in conflict with. Mice, rats and squirrels were frustrating and damaging but all had a place in the ecosystem and a part to play in the cycle of life, if nothing else. As well with the coyotes that hunted the rodents and small animals – they did cause damage, but they were a necessary and beneficial part of the balance for the pest species – and a way for those species to be managed without poison and minimal trapping. Linking these species with their ecosystem services – despite their destruction and the frustration cause – illustrates a good level of ecologic intelligence; including ecosystems services, predator-prey dynamics, and food-web impacts. Environmental protection and connection to nature have been repeatedly documented as a significant goal and side-effect of involvement with urban agriculture, (Egerer et al., 2018; Hawkins et al., 2013).

UA has also been documented as contributing to a collapsing of nature-society dualism, with participants engaging with non-human elements of their local landscape and environment, (Bailey & Kingsley, 2020; Hawkes & Acott, 2013). This dissolution of nature-society dualism is evident in this research as well. As growers engaged with the less 'desirable' aspects of nature – bugs, mud, storms and more – there was a necessary measure of tolerance that must exist. There is no soil without mud, no produce without pollinators/bugs, and no rain without storms. This acceptance also applies to mammals in this study, with several participants expressing happiness when sighting mammals on site, and at minimum tolerating them within their own growing space. Even many of those who had answered "No" to mammals positively affecting their time or growing area on site were able to present some positive or acceptable aspect of mammal species when prompted. These findings bolster the call for an investigation into the *benefits* of human-wildlife interactions, especially with the inclusion of social science methods, (Soulsbury & White, 2015). Additionally, a majority of participants found human-mammal interactions onsite to be positive – linked to the aesthetics and predators of the sites, and made the urban feel more rural. Bringing the rural to the urban has long been a 'goal' of urban agriculture, often as a strategy to alleviate the ills of urban living, (Lawson, 2005). A perception of an improved ecosystem and a shared space were also among the positive responses, and even one of the neutral responses. Understanding UA as a shared-, multi-species space is a novel finding. However, it does track with the framework of shared-use urban infrastructure, with urban animals making use of human-built landscapes, (Niesner et al., 2021).

Assessments of stakeholders' knowledge of species present within an area is a novel approach within the context of UA. Corroborating species photographed on camera traps and those stakeholders are aware of informed which species were those perceived by growers to be problematic and destructive. Through this, species could be included or excluded from the assessment of attitudes about mammals on site – several species present at Maloca Community Garden, and one species at FreshCity Urban Farms were entirely unacknowledged by growers – and thus, were not the focus of their joy or their ire.

In the field of wildlife management, it is becoming increasingly common to engage with local communities and residents in order to devise, develop and implement management strategies. This engagement not only supports general management strategies, but also conservation and coexistence strategies, (Puri et al., 2024; Soanes & Lentini, 2019). Successful management of human-wildlife conflict is increasingly found to go hand-in-hand with engaging local residents in devising and implementing management strategies, as residents are more likely to engage and make changes if they are part of the management process, (Basak et al., 2023; Treves et al., 2006). Thus, the questions posed to stakeholders assessing current conflict management strategies and seeking potential strategies toward coexistence sought to engage growers in devising on-site, applicable ideas to strive for greater coexistence and decreased conflict. Current conflict management strategies focused on the small rodents, and revolved mainly around crop protection, utilising containers, crop covers, traps and depending on natural predators to handle the pests. Interestingly, the suggestions presented by growers for future coexistence are in direct contrast to more standard management strategies, which focus on changing human behaviours in order to mitigate and prevent problematic wildlife behaviours, (Puri et al., 2024). The strategies of coexistence presented focused much more on bolstering the effects of predators to better manage pests, as well as decreasing denning and foraging opportunities for pests, and even increasing ecosystem understanding of both growers' and visitors on both sites.

The results of the questionnaire posed to growers at Maloca Community Garden and FreshCity Urban Farms produced varied results. Many of the responses were in line with previous research highlighting increased environmental connection, protection and dissolving nature-society dualism. However, some responses were in contrast to current management trends. Additionally, some growers' perception of UA as a shared-use, multi-species space is at the cutting edge of urban ecology research, and will hopefully be expanded upon in future work.

5.3 Synthesis of Mammal Diversity, Behaviour and Human Reaction

Urban mammals are often found in our backyards, parks, and marginal habitats on roadsides, and of course where we grow our food, (Angold et al., 2006; Niesner et al., 2021). These species draw a huge range of reactions from human urban residents, from being cute, engaging creatures to disgusting, scary beasts, (Brookshire, 2022; Donovan, 2015; Wilson, 2023). These reactions can usually be attributed to our experiences with these animals, most notably through their behaviour toward us, our homes, and '*our*' greenspaces. These relationships are brought even more to the forefront in urban agricultural spaces, as people work to grow food, flowers and sometimes medicinal plants, and mammals move in to take a share of the produce, without doing any of the 'work'.

The species of mammals and their behaviour in urban agriculture impacts the thoughts, reactions and behaviours of the people involved in those same spaces. In turn, the reactions and behaviours of the stakeholders inform and change mammal species' presence and behaviours. This is an increasingly common theme in human-wildlife conflict and coexistence research, as more and more research finds that local peoples' behaviour patterns have a large impact on local species' behaviour, (Ditchkoff et al., 2006; Frank et al., 2019; Nyhus, 2016). It is a cyclic-, somewhat commensal, possibly mutualistic, but ultimately fraught relationship. The cyclic nature of the relationship is apparent from the changes wrought on behaviour as people and mammals react to the actions of the other. As squirrels, deer and rats nibble on produce and den in compost, stakeholders seek ways to protect their produce and halt the denning of undesirable mammals. As solutions are enacted, mammal behaviours are adapted to the change.

A possibly mutualistic relationship mainly exists with growers and those mammals that positively impacted urban agriculture. Especially species that were nice to see, whose presence brought stakeholders joy. Even more so, species that were known to be providing ecosystem services in the elimination of pests and weeds, and adding nutrients could be considered in a mutualistic relationship with gardeners and farmers. These species were acknowledged even by those who did not agree that mammals positively affected their growing space as having some beneficial behaviours. Coyotes were the clearest example of this, as the species held a complex relationship with stakeholders. This was especially true at FCUFs, where even though they hunted mice and rats, the damage left behind on crop covers frustrated farmers. These frustrations manifested mainly in discussion or purchasing of stronger covers, though they were also damaged. The pest management provided by coyotes was important enough to avoid attempts at exclusion, but the damage still resulted in frustration and mitigation. There are many studies about coyotes in the urban landscape, they are the most studied urban carnivore from 2011-2020, (Collins et al., 2021). However, the author could not find one study in relation to any ecosystem services or benefits to urban residents or coyotes. There were many studies about urban residents' perceptions and beliefs about coyotes, as well as the politics of wildlife and its management, (Gehrt et al., 2011; Hunold & Lloro, 2022; Nardi et al., 2020; Whitley et al., 2023). Raccoons, another example in this study, are a subject of much wildlife management research, as they are one of the most adaptable species in urban environments, often learning to circumvent human-wildlife conflict prevention measures to get into garbage, sheds and homes, (Prange & Gehrt, 2004; Stanton et al., 2022). Raccoons in this research were necessary and helpful predators and scavengers. By eating dropped produce, smaller mammals, slugs and compost, they provided an ecosystem service of pest management. Additionally, they were another species that growers enjoyed seeing, even if they were somewhat disgruntled by damage done. Even the small mammals were acceptable in some instances – for the services of nutrient addition, and predator attraction.

Reactions to mammals that stakeholders were not *quite* as aware of is nearly non-existent. No one suggested destroying the den underneath Maloca Community Garden's shed, or that barriers be put up for the striped skunk that visited FreshCity Urban Farms. These species, particularly the groundhog, mink, opossum, and striped skunk were more or less undisturbed by human attempts at behaviour mitigations, as they were unknown to stakeholders, and were not leaving behind any obvious sign of their presence through prints or damage. Two of those species were also almost exclusively nocturnal – the opossum and the striped skunk, nocturnality in opossums may be somewhat responsible for their somewhat less combative relationship with urban residents in general, (Mims et al., 2022). Interestingly, several of the 'invisible' mammal species in these sites were also beneficial predators. Opossum and striped skunk are predominantly insectivores, feeding on insects (Insecta) and slugs (Gastropoda) but will supplement their diet with other small mammals, (Amspacher, 2022; Fidino et al., 2016). These species were likely hunting the mice that so pestered the growers and farmers of both Maloca Community Garden and FreshCity Urban Farms. Striped skunks are a non-charismatic species, often avoided or harmed due to their spraying behaviour and potential spreading of rabies, (Allen et al., 2022). However, in both Maloca Community Garden and FreshCity Urban Farms, striped skunks are a non-issue, they're an unknown, non-problematic species for growers. As such, they are afforded both foraging and denning opportunities that otherwise may have been destroyed or prevented. Thus, a somewhat commensal relationship exists between stakeholders and mammals they are not aware of. The mammals are benefitting from the produce, infrastructure, and pests on site, while growers are benefitted in other ways, through the addition of nutrients, and predation on pest species. Additionally, the gardeners and farmers are largely unaware of their presence, and thus are neither frustrated nor delighted by these mammal species. This follows research findings illustrating some mammal species, especially omnivores, are taking advantage of the cityscape, while avoiding human interactions and disturbance, (Chatelain & Szulkin, 2020).

The species with the least complex relationship were those that were the most prevalent and most destructive, squirrels, mice, and rats. These species were well known for damaging the tomatoes in MCG, and the irrigation lines in FCUFs. Growers at MCG were much more frustrated and focused on the damaged and ruined produce, while farmers at FCUFs were focused on damaged irrigation lines, and other infrastructure. These were species that received the most attempts at behaviour modification. Fencing put up to deter larger mammals from nibbling on tomatoes was no match for the squirrels, they went over it, or through it as needed to reach their prize – one they would not fully consume anyway. This research did not see a satisfactory solution for the damaged irrigation lines either, they were moved, mice followed, and replaced with stronger ones, still chewed on. All rodents, and rats in particular are impossible to fully exclude from any part of the urban landscape, they multiply too quickly and are too mobile for population control to keep species effectively extinguished, (Byers et al., 2019). However, in this study, despite these conflicts, mice and rats were appreciated at least a little bit for attracting predators to FCUFs. This balanced reaction further illustrates the tolerance of mammals in spaces where people are expecting to *truly* interact with nature, not just walk/run/play through it.

The growers and mammals of Maloca Community Garden and FreshCity Urban Farms impact each other in cycles, throughout the growing season. As mammals make their presence known, growers react accordingly with attempts at prevention and modification, causing the cycle to repeat as mammals adapt again. Yet, even with this continual back and forth, growers do enjoy seeing some of these species, and find their experience of urban agriculture at least somewhat enhanced by their presence. Mammals moving through and living in the cityscape make use of the built environment, with culverts, underpasses, and cemeteries being well-documented and even designed for avenues for wildlife movement, foraging and denning, (Niesner et al., 2021). This research begins to recognize urban agriculture as a social-ecological shared-use space. Throughout this research, it is clear that urban agriculture is a multi-species, multi-use space, with conflict and coexistence woven throughout the space and experience.

These findings build on the expanding field of human-wildlife coexistence, by examining the cyclical relationship between mammals are growers in urban agriculture. The species and behaviour of urban mammals within urban agriculture determine the likelihood of successful coexistence or an increase in conflict between species and growers. Their behaviour is often a reaction to ours, usually leading to an adjustment in our behaviour, and subsequent modification of theirs. Support for conservation and coexistence with wildlife is much more effective when local communities are engaged with conservation programming, education and efforts, (Puri et al., 2024; Soanes & Lentini, 2019). Local residents can have a positive-impact on devising and implementing management strategies for both decreasing conflicts and increasing coexistence, and are often critical to the success of these strategies, (Basak et al., 2023; Puri et al., 2024; Treves et al., 2006). As evidenced by questionnaire responses, the richness of species and behaviour, mammals are firmly entrenched in urban agricultural landscapes, and exclusion is often not even truly considered. Thus, urban agriculture, where interactions (direct or through damage) are more or less unavoidable, will continue to be an invaluable testing grounds for wildlife management strategies, damage mitigation, and conservation biology.

This study exemplifies that coexistence is possible with many species that would normally be considered pest and nuisance animals, if they are in a space where tolerance and acceptance is more normalized than not. The research also demonstrates the potential of geography and landscape as an avenue of study in human-wildlife coexistence, especially as pertains to the human dimensions of coexistence and conflict. Urban greenspaces must be managed to increase biodiversity and conservation, but must also benefit human residents – these two goals will need to be carefully balanced in order to support and enhance them both, (Aronson et al., 2017) Urban wildlife is only increasing in diversity, richness and abundance, with behaviours becoming more adapted to the city, and interactions more prevalent. This research has illuminated some of the minutia within and between the fields of urban agriculture and urban wildlife – biodiversity, behaviour, human-animal conflict and coexistence – and the impacts of these on each other.

6. Conclusion

This research fits squarely into many of the niches explored in the literature. It jointly examines the social and ecological happenings of two urban agriculture sites, using both social and natural science to foster a holistic, multispecies understanding of these spaces in the urban landscape. Understanding the behaviors of urban mammals and the reactions of the people effected is of critical importance for furthering conservation in the city. If human-animal conflicts can be avoided and mitigated, there could be more space for encouraging higher biodiversity in the urban landscape. Additionally, understanding the drivers of conflict and the drivers of coexistence is necessary to better the lives of wildlife and us in the city. Quality of life increases with access to quality greenspaces, both for us and wildlife, but as we build and retrofit greenspaces in 'our' urban landscapes, we find out just how attractive they are to the local wildlife. This research supports the integration of urban ecologic and social needs with policy development. Urban developmental policy will be increasingly driven by sustainability and climate change. The greenspaces that come from these policies must be designed with urban wildlife in mind, as they are a fact of urban life.

Urban agriculture is beneficial to the people who create it, the people who grow it, and the community at large. It benefits the local mammal community, with many species seeking out crops and denning spaces for their own needs. These varying uses of urban agriculture spaces foster conflict, between people and mammals, and among mammal species themselves. Conversely, there is also an enhanced coexistence in these spaces, with several species; striped skunks, coyotes, and rats for example; normally reacted to with fear, forced movement or lethal management were allowed to persist where they were. These species also coexisted with each other, opossum did not win the den, but still appears after the conflict, moving around Maloca Community Garden with no trouble. The human-wildlife coexistence found in urban agriculture is likely due to the unique feature of UA as a space where people come to specifically engage with, manage and *grow* nature. Growers are expecting to encounter the imperfect natural, as opposed to golfers or park-goers, going to meticulously planned, manicured parks and golf courses. Co-examining the behaviour of mammals and the opinions of growers supports future investigation of mitigation strategies, and working to balance negative interactions and conflict with positive interactions and coexistence.

The single commonality between all these species is *where* they are. They are not in a private home, or garden, nor a public shop or manicured greenspace. They are within the bounds of urban agriculture, a space where specific people come to grow plants, by connecting with urban nature. Growers are those who seek to engage with plants, at a bare minimum in order to benefit from their produce. But as many studies have shown, urban agriculture has a much bigger impact than just the harvest. It creates bonds with community, with nature, and as shown here, with wildlife too. The human-mammal relationships investigated were complex, somewhat commensal, and fraught with potential conflict. Yet, these relationships were suffused with a level of tolerance, acceptance and coexistence not often seen in studies of urban animals. Much of the field of urban wildlife is understandably focused on conflict management, with many of the species appearing here also needing regular management. However, in this study, beyond the placing of a few mouse traps in the greenhouses, these species were accepted as a fact of the landscape, a fact of urban agriculture.

While the foraging of mice and rats on produce is understandably frustrating for farmers and gardeners, these species are impossible to fully exclude from urban landscapes, and urban agriculture. However, 'inviting' predators into urban agriculture could provide a potential control for pest species, ranging from insects up to small mammals. Skunks, groundhogs, cats, foxes, and coyotes all predate on pest species, ranging from snails or slugs up to squirrels and rabbits. Leaning into some of the environmental benefits of species would likely help reduce frustration for stakeholders, and create a more ecologically balanced agricultural site. Excluding larger mammals often means excluding predators that could be beneficial in controlling pest populations. Working out appropriate species to attract or exclude is one avenue of possible future research on urban agriculture.

Future work is needed in a multitude of directions. Expanding the number of sites, growers and taxa would increase the applicability of any solutions developed. A focus on testing mitigation strategies would also benefit these sites and urban conservation studies. Deeper investigations into the emotions of growers and the impact on their thoughts and reactions to urban animals is necessary for further understanding the dynamics of these shared spaces. Studies of the movement of mammals through the urban landscape, with a focus on UA and other potential oases would create a better understanding of the urban mammalian landscape, including shared-use infrastructure, and green, wildlife corridors. Cities are expanding, and warming along with the rest of the world, and will need to address these matters. As urban development increasingly centers sustainability policies, research into balancing our needs with the needs of other urban residents will become ever more relevant.

7. Bibliography:

(TRCA), T. a. R. C. A. (2010). Black Creek Pioneer Village North, Terrestrial Biological Inventory and Assessment. In.

Alagona, P. S. (2022). *The accidental ecosystem : people and wildlife in American cities*. University of California Press.

Alaimo, K., Beavers, A. W., Crawford, C., Snyder, E. H., & Litt, J. S. (2016). Amplifying health through community gardens: A framework for advancing multicomponent, behaviorally based neighborhood interventions. *Current environmental health reports*, *3*(3), 302-312.

Alaimo, K., Crawford, C., & Snyder, E. H. (2016). Harvesting Health in the Garden. In E. Hodges Snyder, K. McIvor, & S. Brown (Eds.), *Sowing Seeds in the City: Human Dimensions* (pp. 65-75). Springer Netherlands. https://doi.org/10.1007/978-94-017-7456-7_5

Alaimo, K., Packnett, E., Miles, R. A., & Kruger, D. J. (2008). Fruit and vegetable intake among urban community gardeners. *Journal of nutrition education and behavior*, *40*(2), 94-101.

Allen, M. L., Green, A. M., & Moll, R. J. (2022). Habitat productivity and anthropogenic development drive rangewide variation in striped skunk (Mephitis mephitis) abundance. *Global Ecology and Conservation*, *39*, e02300. https://doi.org/https://doi.org/10.1016/j.gecco.2022.e02300

Amspacher, K. M. (2022). *Striped Skunk Ecology Across an Urban-Rural Gradient in Southern Illinois*. Southern Illinois University at Carbondale.

Anderson, V., & Gough, W. A. (2022). Nature-based cooling potential: a multi-type green infrastructure evaluation in Toronto, Ontario, Canada. *International Journal of Biometeorology*, *66*(2), 397-410. https://doi.org/10.1007/s00484-021-02100-5

Angold, P., Sadler, J. P., Hill, M. O., Pullin, A., Rushton, S., Austin, K.,...Sanderson, R. (2006). Biodiversity in urban habitat patches. *Science of the Total environment*, *360*(1-3), 196-204.

Anton, V., Hartley, S., Geldenhuis, A., & Wittmer, H. U. (2018). Monitoring the mammalian fauna of urban areas using remote cameras and citizen science. *Journal of urban ecology*, *4*(1). https://doi.org/10.1093/jue/juy002

Aronson, M. F. J., Lepczyk, C. A., Evans, K. L., Goddard, M. A., Lerman, S. B., MacIvor, J. S.,...Vargo, T. (2017). Biodiversity in the city: key challenges for urban green space management. *Frontiers in ecology and the environment*, *15*(4), 189-196. https://doi.org/10.1002/fee.1480

Bailey, A., & Kingsley, J. (2020). Connections in the garden: opportunities for wellbeing. *Local Environment*, *25*(11-12), 907-920.

Baker, L. E. (2004). Tending cultural landscapes and food citizenship in Toronto's community gardens. *Geographical review*, *94*(3), 305-325.

Basak, S. M., Rostovskaya, E., Birks, J., & Wierzbowska, I. A. (2023). Perceptions and attitudes to understand human-wildlife conflict in an urban landscape – A systematic review. *Ecological Indicators*, *151*, 110319. https://doi.org/https://doi.org/10.1016/j.ecolind.2023.110319

Beavers, A. W., Atkinson, A., & Alaimo, K. (2020). How gardening and a gardener support program in Detroit influence participants' diet, food security, and food values. *Journal of Hunger & Environmental Nutrition*, *15*(2), 149-169.

Beilin, R., & Hunter, A. (2011). Co-constructing the sustainable city: how indicators help us "grow" more than just food in community gardens. *Local Environment*, *16*(6), 523-538.

Berry, T. (1988). *The dream of the earth*. Sierra Club Books.

Blair, R. B. (1996). Land use and avian species diversity along an urban gradient. *Ecological applications*, *6*(2), 506-519.

Bradfield, A. A., Nagy, C. M., Weckel, M., Lahti, D. C., & Habig, B. (2022). Predictors of Mammalian Diversity in the New York Metropolitan Area. *Frontiers in Ecology and Evolution*, *10*, 903211.

Brault, R. (2010). The Hidden Value of Allotment Gardens in the Urban Context: The Alex Wilson Community Garden, Toronto. *Public*.

Brookshire, B. (2022). *Pests : how humans create animal villains* (First edition. ed.) [still image]. Ecco, an imprint of HarperCollins Publishers.

Burton, A. C., Beirne, C., Sun, C., Granados, A., Procko, M., Chen, C.,...Burgar, J. (2022). Behavioral "bycatch" from camera trap surveys yields insights on prey responses to human-mediated predation risk. *Ecology and Evolution*, *12*(7), e9108. https://doi.org/https://doi.org/10.1002/ece3.9108

Burton, A. C., Neilson, E., Moreira, D., Ladle, A., Steenweg, R., Fisher, J. T.,...Boutin, S. (2015). REVIEW: Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. *Journal of Applied Ecology*, *52*(3), 675-685. https://doi.org/https://doi.org/10.1111/1365-2664.12432

Byers, K. A., Lee, M. J., Patrick, D. M., & Himsworth, C. G. (2019). Rats about town: A systematic review of rat movement in urban ecosystems. *Frontiers in Ecology and Evolution*, *7*, 13.

Caravaggi, A., Banks, P. B., Burton, A. C., Finlay, C. M. V., Haswell, P. M., Hayward, M. W.,...Wood, M. D. (2017). A review of camera trapping for conservation behaviour research. *Remote Sensing in Ecology and Conservation*, *3*(3), 109-122. https://doi.org/https://doi.org/10.1002/rse2.48

Chappell, M. J., & LaValle, L. A. (2011). Food security and biodiversity: can we have both? An agroecological analysis. *Agriculture and human values*, *28*(1), 3-26.

Chatelain, M., & Szulkin, M. (2020). Mammals in urban environments. In *The Routledge Handbook of Urban Ecology* (pp. 383-398). Routledge.

Clarke, L. W., & Jenerette, G. D. (2015). Biodiversity and direct ecosystem service regulation in the community gardens of Los Angeles, CA. *Landscape Ecology*, *30*(4), 637-653.

Clifford, N., Cope, M., Gillespie, T., & French, S. (2016). *Key methods in geography*. Sage.

Clucas, B., Parker, I. D., & Feldpausch-Parker, A. M. (2018). A systematic review of the relationship between urban agriculture and biodiversity. *Urban Ecosystems*, *21*(4), 635-643.

Collins, M. K., Magle, S. B., & Gallo, T. (2021). Global trends in urban wildlife ecology and conservation. *Biological conservation*, *261*, 109236. https://doi.org/10.1016/j.biocon.2021.109236

Cranz, G., & Boland, M. (2004). Defining the Sustainable Park: A Fifth Model for Urban Parks. *Landscape Journal*, *23*(2), 102-120. https://doi.org/10.3368/lj.23.2.102

Delshad, A. B. (2022). Community Gardens: An Investment in Social Cohesion, Public Health, Economic Sustainability, and the Urban Environment. *Urban Forestry & Urban Greening*, 127549.

Ditchkoff, S. S., Saalfeld, S. T., & Gibson, C. J. (2006). Animal behavior in urban ecosystems: modifications due to human-induced stress. *Urban ecosystems*, *9*(1), 5-12.

Donovan, T. (2015). *Feral cities: adventures with animals in the urban jungle*. Chicago Review Press.

Draper, C., & Freedman, D. (2010). Review and analysis of the benefits, purposes, and motivations associated with community gardening in the United States. *Journal of Community Practice*, *18*(4), 458-492.

Dyment, J. E. (2005). Gaining ground. *The power and potential of school ground greening in the Toronto District School*.

Egerer, M., & Cohen, H. (2020). *Urban agroecology: interdisciplinary research and future directions* (Vol. 23). CRC Press.

Egerer, M. H., Bichier, P., & Philpott, S. M. (2017). Landscape and local habitat correlates of lady beetle abundance and species richness in urban agriculture. *Annals of the Entomological Society of America*, *110*(1), 97-103.

Egerer, M. H., Philpott, S. M., Bichier, P., Jha, S., Liere, H., & Lin, B. B. (2018). Gardener well-being along social and biophysical landscape gradients. *Sustainability*, *10*(1), 96.

Faeth, S. H., Bang, C., & Saari, S. (2011). Urban biodiversity: patterns and mechanisms. *Annals of the New York Academy of Sciences*, *1223*(1), 69-81.

Fascione, N., Delach, A., & Smith, M. E. (2004). *People and predators : from conflict to coexistence*. Island Press.

Fidino, M., Gallo, T., Lehrer, E. W., Murray, M. H., Kay, C. A. M., Sander, H. A.,...Magle, S. B. (2021). Landscape-scale differences among cities alter common species' responses to urbanization. *Ecological applications*, *31*(2), e02253-n/a. https://doi.org/10.1002/eap.2253

Fidino, M. A., Lehrer, E. W., & Magle, S. B. (2016). Habitat dynamics of the Virginia opossum in a highly urban landscape. *The American Midland Naturalist*, *175*(2), 155-167.

Firth, C., Maye, D., & Pearson, D. (2011). Developing "community" in community gardens. *Local Environment*, *16*(6), 555-568.

Frank, B., Glikman, J. A., & Marchini, S. (2019). *Human–wildlife interactions: turning conflict into coexistence* (Vol. 23). Cambridge University Press.

Furness, W. W., & Gallaher, C. M. (2018). Food access, food security and community gardens in Rockford, IL. *Local Environment*, *23*(4), 414-430.

Gallo, T., & Fidino, M. (2018). Making wildlife welcome in urban areas. *eLife*, *7*. https://doi.org/10.7554/eLife.41348

Gallo, T., Fidino, M., Lehrer, E. W., & Magle, S. B. (2017). Mammal diversity and metacommunity dynamics in urban green spaces: implications for urban wildlife conservation. *Ecological applications*, *27*(8), 2330-2341. https://doi.org/10.1002/eap.1611

Gehrt, S. D., Brown, J. L., & Anchor, C. (2011). Is the urban coyote a misanthropic synanthrope? The case from Chicago. *Cities and the Environment (CATE)*, *4*(1), 3.

Gehrt, S. D., Riley, S. P. D., & Cypher, B. L. (2010). *Urban carnivores : ecology, conflict, and conservation*. Johns Hopkins University Press.

Genter, C., Roberts, A., Richardson, J., & Sheaff, M. (2015). The contribution of allotment gardening to health and wellbeing: A systematic review of the literature. *British Journal of Occupational Therapy*, *78*(10), 593-605.

Goddard, M. A., Dougill, A. J., & Benton, T. G. (2010). Scaling up from gardens: biodiversity conservation in urban environments. *Trends in ecology & evolution*, *25*(2), 90-98.

Grade, A. M., Warren, P. S., & Lerman, S. B. (2022). Managing yards for mammals: Mammal species richness peaks in the suburbs. *Landscape and Urban Planning*, *220*, 104337.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. *science*, *319*(5864), 756-760.

Guitart, D., Pickering, C., & Byrne, J. (2012). Past results and future directions in urban community gardens research. *Urban forestry & urban greening*, *11*(4), 364-373.

Hanbazaza, M. A., Triador, L., Ball, G. D., Farmer, A., Maximova, K., Nation, A. F., & Willows, N. D. (2015). The impact of school gardening on Cree children's knowledge and attitudes toward vegetables and fruit. *Canadian Journal of Dietetic Practice and Research*, *76*(3), 133-139.

Hansen, C. P., Parsons, A. W., Kays, R., & Millspaugh, J. J. (2020). Does use of backyard resources explain the abundance of urban wildlife? *Frontiers in Ecology and Evolution*, 374.

Hawkes, F. M., & Acott, T. G. (2013). People, environment and place: The function and significance of human hybrid relationships at an allotment in South East England. *Local environment*, *18*(10), 1117-1133.

Hawkins, J. L., Mercer, J., Thirlaway, K. J., & Clayton, D. A. (2013). "Doing" gardening and "being" at the allotment site: Exploring the benefits of allotment gardening for stress reduction and healthy aging. *Ecopsychology*, *5*(2), 110-125.

Herbert, D. T., & Matthews, J. A. (2004). *Unifying Geography: Common heritage, shared future* (1 ed.). Routledge. https://doi.org/10.4324/9780203611395

Hermann, J. R., Parker, S. P., Brown, B. J., Siewe, Y. J., Denney, B. A., & Walker, S. J. (2006). After-school gardening improves children's reported vegetable intake and physical activity. *Journal of Nutrition Education and Behavior*, *38*(3), 201-202.

Herrera, D. J., Moore, S. M., Flockhart, D. T., McShea, W. J., & Cove, M. V. (2021). Thinking outside the park: recommendations for camera trapping mammal communities in the urban matrix. *Journal of Urban Ecology*, *7*(1), juaa036.

Holland, L. (2004). Diversity and connections in community gardens: A contribution to local sustainability. *Local environment*, *9*(3), 285-305.

Hunold, C., & Lloro, T. (2022). There goes the neighborhood: Urban coyotes and the politics of wildlife. *Journal of Urban Affairs*, *44*(2), 156-173. https://doi.org/10.1080/07352166.2019.1680243

Ives, C. D., Lentini, P. E., Threlfall, C. G., Ikin, K., Shanahan, D. F., Garrard, G. E.,...Rayner, L. (2016). Cities are hotspots for threatened species. *Global Ecology and Biogeography*, *25*(1), 117-126.

Kays, R., Arbogast, B. S., Baker-Whatton, M., Beirne, C., Boone, H. M., Bowler, M.,...Spironello, W. R. (2020). An empirical evaluation of camera trap study design : How many, how long and when? *Methods in ecology and evolution*, *11*(6), 700-713. https://doi.org/10.1111/2041-210X.13370

Kondo, M., Hohl, B., Han, S., & Branas, C. (2016). Effects of greening and community reuse of vacant lots on crime. *Urban Studies*, *53*(15), 3279-3295.

Konijnendijk, C. (2012). Between fascination and fear–The impacts of urban wilderness on human health and wellbeing. *Socialmedicinsk tidskrift*, *89*(3), 289-295.

Koprowski, J. L., Munroe, K. E., & Edelman, A. J. (2016). Gray not grey: Ecology of Sciurus carolinensis in their native range in North America. *The Grey Squirrel: ecology & management of an invasive species in Europe. Woodbridge, Suffolk UK: European Squirrel Initiative*, 1-18.

Lawson, L. J. (2005). *City bountiful: A century of community gardening in America*. Univ of California Press.

Lee, S.-M., Jang, H.-J., Yun, H.-K., Jung, Y.-B., & Hong, I.-K. (2022). Effect of Apartment Community Garden Program on Sense of Community and Stress. *International Journal of Environmental Research and Public Health*, *19*(2), 708.

Lehrer, E., Schooley, R., & Whittington, J. (2012). Survival and antipredator behavior of woodchucks (Marmota monax) along an urban–agricultural gradient. *Canadian Journal of Zoology*, *90*(1), 12-21.

Lehrer, E. W., & Schooley, R. L. (2010). Space use of woodchucks across an urbanization gradient within an agricultural landscape. *Journal of Mammalogy*, *91*(6), 1342-1349.

Lin, B. B., Philpott, S. M., & Jha, S. (2015). The future of urban agriculture and biodiversity-ecosystem services: Challenges and next steps. *Basic and applied ecology*, *16*(3), 189-201.

Long, R. A. (2008). *Noninvasive survey methods for carnivores*. Island Press.

Lorimer, J. (2012). Multinatural geographies for the Anthropocene. *Progress in human geography*, *36*(5), 593-612. https://doi.org/10.1177/0309132511435352

Lowry, H., Lill, A., & Wong, B. B. (2013). Behavioural responses of wildlife to urban environments. *Biological reviews*, *88*(3), 537-549.

Magle, S. B., Hunt, V. M., Vernon, M., & Crooks, K. R. (2012). Urban wildlife research: past, present, and future. *Biological conservation*, *155*, 23-32.

Malberg Dyg, P., Christensen, S., & Peterson, C. J. (2020). Community gardens and wellbeing amongst vulnerable populations: a thematic review. *Health promotion international*, *35*(4), 790-803.

Maller, C., Townsend, M., Pryor, A., Brown, P., & St Leger, L. (2006). Healthy nature healthy people:'contact with nature'as an upstream health promotion intervention for populations. *Health promotion international*, *21*(1), 45-54.

Manlick, P. J., Windels, S. K., Woodford, J. E., & Pauli, J. N. (2020). Can landscape heterogeneity promote carnivore coexistence in human-dominated landscapes? *Landscape Ecology*, *35*(9), 2013-2027.

McCabe, A. (2014). Community gardens to fight urban youth crime and stabilize neighborhoods. *International Journal of Child Health and Human Development*, *7*(3).

McLafferty, S. (2003). Conducting questionnaire surveys. Key Methods in Geography. Edited by: Clifford NJ, Valentine G. In: London: Sage Publications.

Mims, D. M., Yasuda, S. A., & Jordan, M. J. (2022). CONTRASTING ACTIVITY TIMES BETWEEN RACCOONS (PROCYON LOTOR) AND VIRGINIA OPOSSUMS (DIDELPHIS VIRGINIANA) IN URBAN GREEN SPACES. *Northwestern Naturalist*, *103*(1), 63-75. https://doi.org/10.1898/1051-1733-103.1.63

Mueller, M. A., Drake, D., & Allen, M. L. (2018). Coexistence of coyotes (Canis latrans) and red foxes (Vulpes vulpes) in an urban landscape. *PLOS ONE*, *13*(1), e0190971. https://doi.org/10.1371/journal.pone.0190971

Mundel, E., & Chapman, G. E. (2010). A decolonizing approach to health promotion in Canada: the case of the Urban Aboriginal Community Kitchen Garden Project. *Health Promotion International*, *25*(2), 166-173.

Nardi, A., Shaw, B., Brossard, D., & Drake, D. (2020). Public attitudes toward urban foxes and coyotes: the roles of perceived risks and benefits, political ideology, ecological worldview, and attention to local news about urban wildlife. *Human Dimensions of Wildlife*, *25*(5), 405-420. https://doi.org/10.1080/10871209.2020.1748768

Niemela, J. (1999). Ecology and urban planning. *Biodiversity and conservation*, *8*(1), 119-131. https://doi.org/10.1023/A:1008817325994

Niesner, C. A., Blakey, R. V., Blumstein, D. T., & Abelson, E. S. (2021). Wildlife Affordances of Urban Infrastructure: A Framework to Understand Human-Wildlife Space Use [Original Research]. *Frontiers in Conservation Science*, *2*. https://doi.org/10.3389/fcosc.2021.774137

Nyhus, P. J. (2016). Human–wildlife conflict and coexistence. *Annual review of environment and resources*, *41*, 143-171.

O'Connell, A. F., Nichols, J. D., Karanth, K. U., Kucera, T. E., Barrett, R. H., Swann, D. E.,...Wibisono, H. T. (2011). *Camera traps in animal ecology : methods and analyses / Allan F. O'Connell, James D. Nichols, K. Ullas Karanth, editors*. Springer Verlag.

Ober Allen, J., Alaimo, K., Elam, D., & Perry, E. (2008). Growing vegetables and values: Benefits of neighborhood-based community gardens for youth development and nutrition. *Journal of Hunger & Environmental Nutrition*, *3*(4), 418-439.

Ohmer, M. L., Meadowcroft, P., Freed, K., & Lewis, E. (2009). Community Gardening and Community Development: Individual, Social and Community Benefits of a Community Conservation Program. *Journal of Community Practice*, *17*(4), 377-399. https://doi.org/10.1080/10705420903299961

Okvat, H. A., & Zautra, A. J. (2011). Community gardening: A parsimonious path to individual, community, and environmental resilience. *American journal of community psychology*, *47*(3), 374-387.

Ong, T. W. Y., & Fitch, G. (2020). How to Study the Ecology of Food in the City: An Overview of Natural Science Methodologies. *Urban Agroecology*, 247-274.

Park, S.-A., Lee, A.-Y., Lee, K.-S., & Son, K.-C. (2014). Gardening tasks performed by adults are moderate-to high-intensity physical activities. *HortTechnology*, *24*(1), 58-63.

Pease, B. S., Nielsen, C. K., & Holzmueller, E. J. (2016). Single-Camera Trap Survey Designs Miss Detections: Impacts on Estimates of Occupancy and Community Metrics. *PLOS ONE*, *11*(11), e0166689. https://doi.org/10.1371/journal.pone.0166689

Peng, J., Liu, Z., Liu, Y., Hu, X., & Wang, A. (2015). Multifunctionality assessment of urban agriculture in Beijing City, China. *Science of the Total Environment*, *537*, 343-351.

Pickett, S. T. A., Cadenasso, M. L., Grove, J. M., Nilon, C. H., Pouyat, R. V., Zipperer, W. C., & Costanza, R. (2001). Urban Ecological Systems: Linking Terrestrial Ecological, Physical, and Socioeconomic Components of Metropolitan Areas. *Annual review of ecology and systematics*, *32*(1), 127-157. https://doi.org/10.1146/annurev.ecolsys.32.081501.114012

Poulsen, M. N., Hulland, K. R., Gulas, C. A., Pham, H., Dalglish, S. L., Wilkinson, R. K., & Winch, P. J. (2014). Growing an urban Oasis: a qualitative study of the perceived benefits of community gardening in B altimore, M aryland. *Culture, Agriculture, Food and Environment*, *36*(2), 69-82.

Prange, S., & Gehrt, S. D. (2004). Changes in mesopredator-community structure in response to urbanization. *Canadian Journal of Zoology*, *82*(11), 1804-1817.

Puri, M., Goode, K. O., Johannsen, K. L., & Pienaar, E. F. (2024). Engaging urban residents in the appropriate actions to mitigate human–wildlife conflicts. *Conservation Science and Practice*, *6*(2), e13074.

Ramsden, S. (2021). “It’s one of the few things that… pulls us together when the outside world is really tough.” Exploring the outcomes and challenges of a charity-led community garden in a disadvantaged English city. *Local Environment*, *26*(2), 283-296.

Rega-Brodsky, C. C., Aronson, M. F., Piana, M. R., Carpenter, E.-S., Hahs, A. K., Herrera-Montes, A.,…Moretti, M. (2022). Urban biodiversity: State of the science and future directions. *Urban Ecosystems*, 1-14.

Ritzel, K., & Gallo, T. (2020). Behavior change in urban mammals: a systematic review. *Frontiers in Ecology and Evolution*, *8*, 576665.

Rivkin, L. R., Santangelo, J. S., Alberti, M., Aronson, M. F., de Keyzer, C. W., Diamond, S. E.,…Hendry, A. P. (2019). A roadmap for urban evolutionary ecology. *Evolutionary applications*, *12*(3), 384-398.

Rovero, F., Zimmermann, F., Berzi, D., & Meek, P. (2013). "Which camera trap type and how many do I need?" A review of camera features and study designs for a range of wildlife research applications [journal article]. *Hystrix, the Italian Journal of Mammalogy*, *24*(2), 148-156. https://doi.org/10.4404/hystrix-24.2-8789

Rowcliffe, J. M., Kays, R., Kranstauber, B., Carbone, C., & Jansen, P. A. (2014). Quantifying levels of animal activity using camera trap data. *Methods in ecology and evolution*, *5*(11), 1170-1179.

Seto, K. C., Güneralp, B., & Hutyra, L. R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences*, *109*(40), 16083-16088.

Shannon, C. E. (1948). A mathematical theory of communication. *The Bell system technical journal*, *27*(3), 379-423.

Sharma, K., Fiechter, M., George, T., Young, J., Alexander, J. S., Bijoor, A.,...Mishra, C. (2020). Conservation and people: Towards an ethical code of conduct for the use of camera traps in wildlife research. *Ecological Solutions and Evidence*, *1*(2), e12033. https://doi.org/https://doi.org/10.1002/2688-8319.12033

Soanes, K., & Lentini, P. E. (2019). When cities are the last chance for saving species. *Frontiers in Ecology and the Environment*, *17*(4), 225-231.

Soga, M., Cox, D. T., Yamaura, Y., Gaston, K. J., Kurisu, K., & Hanaki, K. (2017). Health benefits of urban allotment gardening: Improved physical and psychological well-being and social integration. *International journal of environmental research and public health*, *14*(1), 71.

Sollmann, R. (2018). A gentle introduction to camera-trap data analysis. *African journal of ecology*, *56*(4), 740-749. https://doi.org/10.1111/aje.12557

Soulsbury, C. D., & White, P. C. (2015). Human–wildlife interactions in urban areas: a review of conflicts, benefits and opportunities. *Wildlife research*, *42*(7), 541-553.

Soulsbury, C. D., & White, P. C. L. (2019). A Framework for Assessing and Quantifying Human–Wildlife Interactions in Urban Areas. In B. Frank, J. A. Glikman, & S. Marchini (Eds.), *Human–Wildlife Interactions: Turning Conflict into Coexistence* (pp. 107-128). Cambridge University Press. https://doi.org/DOI: 10.1017/9781108235730.009

Spellerberg, I. F., & Fedor, P. J. (2003). A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon–Wiener' Index. *Global Ecology and Biogeography*, *12*(3), 177-179. https://doi.org/https://doi.org/10.1046/j.1466-822X.2003.00015.x

Sperling, C. D., & Lortie, C. J. (2010). The importance of urban backgardens on plant and invertebrate recruitment: a field microcosm experiment. *Urban Ecosystems*, *13*(2), 223-235. https://doi.org/10.1007/s11252-009-0114-y

Stanton, L. A., Bridge, E. S., Huizinga, J., & Benson-Amram, S. (2022). Environmental, individual and social traits of free-ranging raccoons influence performance in cognitive testing. *Journal of Experimental Biology*, *225*(18), jeb243726. https://doi.org/10.1242/jeb.243726

Steenweg, R., Hebblewhite, M., Kays, R., Ahumada, J., Fisher, J. T., Burton, C.,...Rich, L. N. (2017). Scaling-up camera traps: monitoring the planet's biodiversity with networks of remote sensors. *Frontiers in ecology and the environment*, *15*(1), 26-34. https://doi.org/10.1002/fee.1448

Sundberg, C. (2005). *Improving compost process efficiency by controlling aeration, temperature and pH*. Swedish University of Agricultural Sciences Uppsala.

Taylor, B., Andrews, D., & Fraser, G. S. (2011). Double-crested cormorants and urban wilderness: conflicts and management. *Urban Ecosystems*, *14*(3), 377-394.

Teig, E., Amulya, J., Bardwell, L., Buchenau, M., Marshall, J. A., & Litt, J. S. (2009). Collective efficacy in Denver, Colorado: Strengthening neighborhoods and health through community gardens. *Health & Place*, *15*(4), 1115-1122. https://doi.org/https://doi.org/10.1016/j.healthplace.2009.06.003

Travaline, K., & Hunold, C. (2010). Urban agriculture and ecological citizenship in Philadelphia. *Local Environment*, *15*(6), 581-590.

Treves, A., Wallace, R. B., Naughton-Treves, L., & Morales, A. (2006). Co-Managing Human–Wildlife Conflicts: A Review. *Human Dimensions of Wildlife*, *11*(6), 383-396. https://doi.org/10.1080/10871200600984265

Tryjanowski, P., Morelli, F., & Møller, A. P. (2020). Urban birds: Urban avoiders, urban adapters, and urban exploiters. In *The Routledge Handbook of Urban Ecology* (pp. 399-411). Routledge.

Van Den Berg, A. E., & Custers, M. H. (2011). Gardening promotes neuroendocrine and affective restoration from stress. *Journal of health psychology*, *16*(1), 3-11.

Van den Berg, A. E., van Winsum-Westra, M., De Vries, S., & Van Dillen, S. M. (2010). Allotment gardening and health: a comparative survey among allotment gardeners and their neighbors without an allotment. *Environmental Health*, *9*(1), 1-12.

Van Patter, L. E. (2021). *(Re)Storying the More-Than-Human City: Urban Coyotes in Canada* (Publication Number 29005952) [Ph.D., Queen's University (Canada)]. ProQuest Dissertations & Theses Global. Ann Arbor. https://ezproxy.library.yorku.ca/login?url=https://www.proquest.com/dissertations-theses/re-storying-more-than-human-city-urban-coyotes/docview/2652590786/se-2?accountid=15182https://ocul-yor.primo.exlibrisgroup.com/openurl/01OCUL_YOR/01OCUL_YOR:YOR_DEFAULT?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&genre=dissertations&sid=ProQ:ProQuest+Dissertations+%26+Theses+Global&atitle=&title=%28Re%29Storying+the+More-Than-Human+City%3A+Urban+Coyotes+in+Canada&issn=&date=2021-01-01&volume=&issue=&spage=&au=Van+Patter%2C+Lauren+Eila&isbn=979-8-209-91683-3&jtitle=&btitle=&rft_id=info:eric/&rft_id=info:doi/

Veen, E. J., Bock, B. B., Van den Berg, W., Visser, A. J., & Wiskerke, J. S. (2016). Community gardening and social cohesion: different designs, different motivations. *Local Environment*, *21*(10), 1271-1287.

Vella, K., Ploderer, B., & Brereton, M. (2021). Human-Nature Relations in Urban Gardens: Explorations with Camera Traps. Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems,

Voicu, I., & Been, V. (2008). The effect of community gardens on neighboring property values. *Real Estate Economics*, *36*(2), 241-283.

Wakefield, S., Yeudall, F., Taron, C., Reynolds, J., & Skinner, A. (2007). Growing urban health: community gardening in South-East Toronto. *Health promotion international*, *22*(2), 92-101.

Wang, H., Qiu, F., & Swallow, B. (2014). Can community gardens and farmers' markets relieve food desert problems? A study of Edmonton, Canada. *Applied Geography*, *55*, 127-137.

Whitley, C. T., Bowers, M. M., & Grantz, H. (2023). Urban Human–Coyote Conflicts: Assessing Friendliness as an Indicator of Coexistence. *Animals*, *13*(18), 2903.

Wilson, B. (2023). *Urban jungle : the history and future of nature in the city* (First American edition. ed.) [still image]. Doubleday.

Wu, J., He, C., Huang, G., & Yu, D. (2013). Urban landscape ecology: Past, present, and future. In *Landscape ecology for sustainable environment and culture* (pp. 37-53). Springer.

Zimmerer, K. S., Bell, M. G., Chirisa, I., Duvall, C. S., Egerer, M., Hung, P.-Y.,...Yacamán Ochoa, C. (2021). Grand challenges in urban agriculture: ecological and social approaches to transformative sustainability. In (Vol. 5, pp. 668561): Frontiers Media SA.

Łopucki, R., Klich, D., & Kitowski, I. (2019). Are small carnivores urban avoiders or adapters: Can they be used as indicators of well-planned green areas? *Ecological indicators*, *101*, 1026-1031.

'Yotti'Kingsley, J., & Townsend, M. (2006). 'Dig in'to social capital: Community gardens as mechanisms for growing urban social connectedness. *Urban Policy and Research*, *24*(4), 525-537.

Appendix A: Research Questionnaire

Questionnaire: Walking Potatoes & Wilder-beasts: An examination of the relationship between humans and mammals in urban agriculture

1. <u>What is your relationship to this urban farm/community garden?</u>
    a. Active Grower/Farmer
    b. Inactive Grower/Farmer
    c. Administrator
    d. Other:

2. <u>How often do you visit your growing plot/the garden?</u>
    a. Daily
    b. Weekly
    c. Twice per month
    d. Once a month
    e. Other:

3. <u>How long do you stay each visit?</u>
    a. 10 minutes or less
    b. 30 minutes or less
    c. 1 hour or less
    d. 1 hour or more
    e. It varies / Other:

4. <u>What time of day do you typically visit?</u>
    a. Early morning
    b. Mid-morning
    c. Early afternoon
    d. Mid-afternoon
    e. Evening

f. Other:

5. <u>What do you grow?</u>
    a. Mostly food
    b. Mostly flowers
    c. Even mix
    d. Medicinal
    e. Other:

6. <u>How many years have you been growing/involved with this urban farm/community garden?</u>
    a. Less than 6 months
    b. 1-2 years
    c. 3-5 years
    d. 5-10 years
7. <u>How has this urban farm/community garden impacted you?</u>
    a. Very positively
    b. Somewhat positively
    c. Neither positively or negatively
    d. Somewhat negatively
    e. Very negatively

8. <u>How do mammals effect your experience of the urban farm/community garden?</u>
    a. Very positively
    b. Somewhat positively
    c. Neither positively or negatively
    d. Somewhat negatively
    e. Very negatively

9. How do mammals effect your experience of your growing plot?
    a. Very positively
    b. Somewhat positively
    c. Neither positively or negatively
    d. Somewhat negatively
    e. Very negatively

10. What do mammals do to negatively affect you or your plot? (choose all that apply)
    a. Eat or nibble plants/food
    b. Trample plants
    c. Damage to fences/posts
    d. Bites/attacks
    e. Other:

11. What is most eaten/destroyed?
    a. Fruit
    b. Vegetables
    c. Herbs
    d. Flowers
    e. Medicinals
    f. Other:

12. How often are things eaten/destroyed? E.g. every visit, several times a season, etc.

13. Do mammals positively affect your plot or time here?
    a. Yes
    b. No

14. <u>Open-ended: What do mammals do that positively affects your plot or time here?</u>

15. Are human-animal interactions here mostly positive or negative?
    a. Positive
    b. Negative
    c. Even/both

16. In your opinion, Why are human-mammal interactions in the urban farm/community garden positive or negative?

17. What species of mammals do you see? (choose all that apply)
    a. Squirrels
    b. Rabbits
    c. Deer
    d. Coyotes
    e. Foxes
    f. Rats
    g. Raccoons
    h. Other:

18. How often do you see them? E.g. every visit, only sometimes, rarely, etc.

19. Which species have the most negative impact?

20. How do you deal with problem mammals in your growing plot?

21. Which species have the most positive impact?

22. How could you increase positive human-animal interactions in the farm/garden?

23. Please rank the following 'types' of animals from best to worst, in terms of your experiences in the urban farm/community garden.
    a. Birds
    b. Bugs
    c. Mammals
    d. Reptiles
    e. Amphibians
    f. Other:

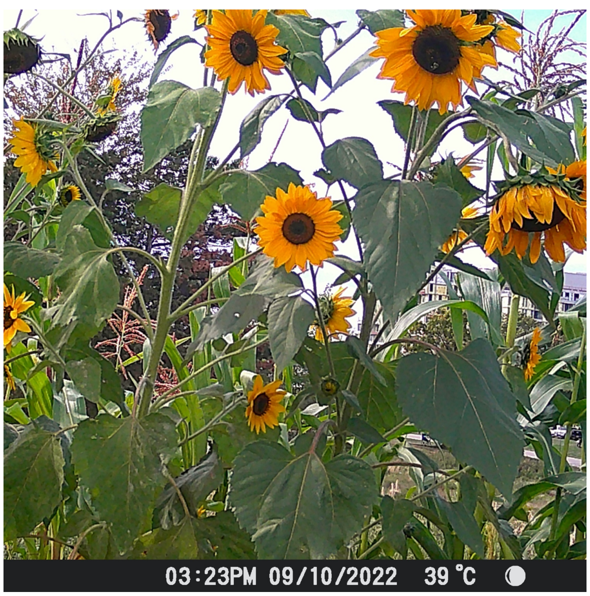
24. FOR ADMIN: How are pest mammals dealt with for the overall farm/garden?

Appendix B: Examples from Reviewed Photosets

MCam FCUFs, 08/26, 7490 photographs

Mcam FCUFs, 08/24-25, 10,000 photographs

MCam FCUFs 09/08-15, 9820 photographs

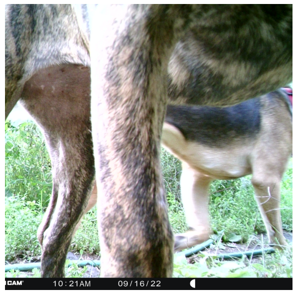


MCam FCUfs 10/07-09, 8127 photographs

Appendix C: Species Documented at Maloca Community Garden

Eastern Grey Squirrel (Sciurus carolinensis)

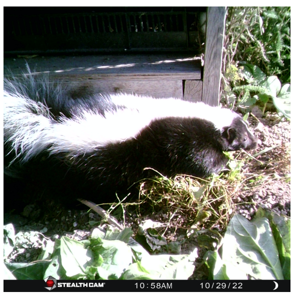
Dog (Canis lupus familiaris)



Cat (Felis catus)

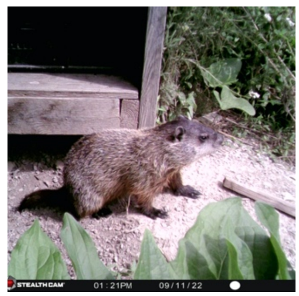
Raccoon (Procyon lotor)

Striped Skunk (Mephitis mephitis



Opossum (Didelphis virginana)

Groundhog (Marmota monax)

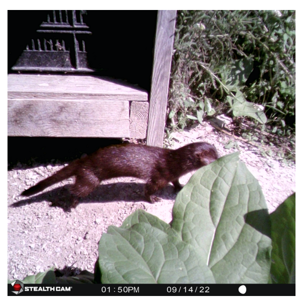


Norway Rat (Rattus Norvegicus)

Rabbit (Sylvilagus floridanus)

Deer (Odocoileus virginianus)

American Mink (Neogale vision)



Mouse (Deer or House)

Coyote (Canis latrans) Sasquatch?

Appendix D: Species Documented at FreshCity Urban Farms

Norway rat (Rattus norvegicus)

Mouse (Deer or House)

Coyote (Canis latrans)

Rabbit (Sylvilagus floridanus)

Striped Skunk (Mephitis mephitis)

Dog (Canis lupus familiaris)

Meadow vole (Microtus pennsylvanicus

Raccoon (Procyon lotor)