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THE INFLUENCES OF PARK ACCESSIBILITY AND DESIGN ON PARK USE AND CROWDING IN THE GREATER MONTREAL AREA

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RÉSUMÉ

Cette thèse explore la relation entre accessibilité, design et le niveau d’achalandage des usagers dans les parcs du Grand Montréal ayant divers degrés d'accessibilité.

L'étude présente trois phases différentes de collecte et d'analyse des données. Tout d'abord, une analyse de l'équité environnementale est réalisée à l'aide de la méthode Enhanced Two-Step Floating Catchment area (intégrant l’achalandage potentiel dans les calculs d’accessibilités), qui utilise des données sur les parcs du Grand Montréal. Ensuite, à partir de données d'observation dans six parcs différents du Grand Montréal, nous analysons l’achalandage et sa variabilité temporelle et spatiale dans les parcs. Enfin, une analyse par sondage est menée dans ces mêmes parcs afin de comprendre les perceptions des gens à l'égard de l’achalandage dans les parcs.

Les résultats montrent que les quartiers ayant d’avantage des enfants ont tendance à avoir des parcs plus loin mais qui disposent de plus d'espaces et d'installations dans les parcs (généralement dans les banlieues). En revanche, les quartiers habités davantage par les personnes à faible revenu et les minorités visibles sont plus près des parcs, mais souffrent de la congestion due au manque d'espace et d'installations dans les parcs (généralement dans les zones denses et centrales). À l’intérieur des parcs, les données d’observation montrent que alors que les installations n'améliorent que parfois les niveaux d’utilisation. Les installations sportives sont des aspects importants des parcs qui attirent les utilisateurs. En outre, dans les parcs suburbains, la fréquentation tend à se produire lorsque des services ou des institutions spécifiques se trouvent à proximité. Enfin, le type d'activités dans les parcs est associé de façon significative avec la durée de la visite, la fréquence des visites et la perception de l'achalandage des parcs, tant au niveau individuel qu'au niveau des cercles sociaux. Les résultats suggèrent également que les visiteurs de l'aire de jeux ont tendance à rester plus longtemps et à percevoir une plus grande congestion que ceux qui ne l’utilisent pas.

Cette étude met en évidence que les méthodes d'observation et les enquêtes permettent de comprendre l'importance des configurations spatiales sur l’achalandage. Cette approche peut aider les urbanistes et les concepteurs à mettre à jour la conception des parcs afin de répondre aux besoins des utilisateurs et d'augmenter la fréquentation en s'éloignant des parcs ayant une configuration unique.

Mots-clés : banlieues; urbain; conception des parcs; capacité d'accueil; densité fonctionnelle; équité environnementale

ABSTRACT

This dissertation explores the relationship between accessibility, design, and crowding in Greater Montreal parks with varying degrees of accessibility.

The study puts forth three different phases of data collection and analysis. Firstly, an environmental equity analysis using the Enhanced Two-Step Floating Catchment Area method (integrating potential congestion into accessibility calculation) and data on Greater Montreal parks is carried out. Second, using observation data from six different Greater Montreal parks, we analyze crowding and its temporal and spatial variability within the parks. Finally, a survey analysis is conducted in these same parks to understand people's perceptions of park crowding.

The results show that that neighborhoods with higher populations of children are generally located farther from parks and tend to have more park space and facilities. However, neighborhoods with larger low-income and visible minority populations are closer to parks and face crowding due to limited park space and amenities (typically in dense and urban core areas). Additionally, while facilities only sometimes improve use levels due to conditions and maintenance, sports facilities are important aspects of parks that attract users. Furthermore, in suburban parks, crowding tends to occur when specific services or institutions are nearby. Finally, the type of activities in the parks is significantly associated with the duration of the visit, the frequency of visits and the perception of park crowding, both at individual and social circle level. The results also suggest that playground visitors tend to stay longer and perceive more crowding than those who do not visit the playground.

This study highlights how observational methods and surveys can be used to understand the importance of spatial configurations on crowding. This approach can help planners and designers update park designs to meet user needs and increase attendance by moving away from parks with a single configuration.

Keywords: suburbs; urban; park design; carrying capacity; functional density; environmental equity

SYNTHÈSE

Cette thèse s'inscrit dans le cadre de la recherche sur l’équité environnementale et l’accès aux parcs urbains. Les parcs, largement étudiés dans les études urbaines, sont reconnus pour leurs bienfaits sur la santé physique, mentale et sociale, ainsi que pour leurs avantages environnementaux, comme la gestion des eaux pluviales et la réduction des îlots de chaleur urbains. Cependant, l'accès inéquitable aux parcs selon les groupes sociaux, notamment les minorités visibles et les populations à faible revenu, soulève des questions sur les iniquités dans la distribution des espaces verts urbains.

La littérature sur l’équité environnementale examine principalement l’accès différencié aux infrastructures publiques, en particulier les parcs, en mettant l’accent sur leur répartition géographique et leur accessibilité. Toutefois, les études basées sur la simple mesure de la proximité spatiale ont été critiquées pour leur incapacité à capturer toute la complexité de l’accessibilité des parcs. Il est donc nécessaire d’intégrer d’autres indicateurs, tels que la congestion potentielle, pour mieux comprendre les iniquités d’accès aux parcs.

Ce projet répond à trois lacunes dans la recherche actuelle :

1. L'absence d'intégration de la congestion dans l'évaluation de l’accessibilité des parcs,
2. Le manque d’analyse de la manière dont la conception des parcs répond aux besoins des quartiers environnants,
3. La non-validation des données de congestion avec les perceptions des utilisateur·trice·s des parcs.

Ce projet comprend trois volets de méthodes (analyse spatiale, observations et enquêtes) et se concentre sur le Grand Montréal, comprenant les municipalités de Montréal, Laval, Longueuil, et la couronne nord et sud. En premier partie, la thèse utilise deux bases de données principales : l’inventaire des parcs et des équipements, ainsi que les données du recensement canadien pour analyser les groupes de population. Trois indicateurs sont calculés pour mesurer l’accessibilité des parcs : la proximité géographique, la congestion potentielle en fonction de la superficie des parcs, et la congestion potentielle selon les équipements disponibles. Ces données sont analysées pour évaluer l'équité environnementale en comparant les différents groupes de population (enfants, personnes âgées, personnes à faible revenu, minorités visibles) à l'aide de tests statistiques et de modèles de régression.

Les résultats montrent que sur le territoire du Grand Montréal (qui inclut près de 4000 parcs), les groupes à faible revenu et les minorités visibles ont un meilleur accès au parc le plus proche, mais ces parcs sont potentiellement plus congestionnés, notamment dans les noyaux urbains. En revanche, les enfants ont un accès significativement plus faible aux parcs. De plus, les modèles de régression ont confirmé que la congestion potentielle varie selon les typologies de parcs (noyau urbain ou banlieue) et les différents groupes de population.

Ensuite, les observations réalisées dans les parcs pendant l'été 2022 révèlent des modèles d'utilisation variés selon les types de parcs. Les parcs de noyau urbain sont caractérisés par une utilisation plus homogène tout au long de la semaine, tandis que les parcs de banlieue présentent une utilisation plus marquée durant les fins de semaine, notamment pour les activités sportives.

Finalement, la perception des utilisateur·trice·s de l'achalandage dans les parcs varie en fonction de l'heure de la visite et de l'activité pratiquée. Les usagers des aires de jeux perçoivent une plus grande densité fonctionnelle, et les heures de visite en après-midi et en soirée sont celles où la densité d'usagers est la plus importante. Enfin, une régression logistique a révélé que la raison principale de la visite (aire de jeux, activités passives) influence fortement la fréquence et la durée des visites, ainsi que la perception de l'achalandage.

Les résultats de cette étude apportent des contributions importantes à la compréhension de l'équité environnementale dans l'accès aux parcs, en soulignant la nécessité d'une approche méthodologique intégrée qui combine l'analyse spatiale et la perception des utilisateur·trice·s. Cette recherche met en évidence les disparités dans l'accès et l'utilisation des parcs et suggère que la simple proximité géographique ne garantit pas un accès équitable à des parcs de qualité. Elle souligne aussi l'importance d'adapter la conception des parcs et de prendre en compte les préférences des utilisateur·trice·s pour une gestion plus équitable et efficace des espaces publics.

Cette étude enrichit les connaissances sur l'utilisation des parcs et les iniquités environnementales en montrant que la répartition des parcs, leur conception et leur utilisation varient considérablement selon les groupes socio-économiques et les quartiers. Il est essentiel de poursuivre les recherches pour affiner les méthodologies et promouvoir une gestion des parcs plus équitable.

FOREWORD

Walking Down Park BY NIKKI GIOVANNI

Source: The Collected Poems of Nikki Giovanni (2003)

walking down park
amsterdam
or columbus do you ever stop
to think what it looked like
before it was an avenue
did you ever stop to think
what you walked
before you rode
subways to the stock
exchange (we can't be on
the stock exchange
we are the stock
exchanged)

did you ever maybe wonder
what grass was like before
they rolled it
into a ball and called
it central park
where syphilitic dogs
and their two-legged tubercular
masters fertilize
the corners and side-walks
ever want to know what would happen
if your life could be fertilized
by a love thought
from a loved one
who loves you

ever look south
on a clear day and not see
time's squares but see
tall Birch trees with sycamores
touching hands
and see gazelles running playfully
after the lions

ever hear the antelope bark
from the third floor apartment

ever, did you ever, sit down
and wonder about what freedom's freedom
would bring
it's so easy to be free
you start by loving yourself
then those who look like you
all else will come
naturally

ever wonder why
so much asphalt was laid
in so little space
probably so we would forget
the Iroquois, Algonquin
and Mohicans who could caress
the earth

ever think what Harlem would be
like if our herbs and roots and elephant ears
grew sending
a cacophony of sound to us
the parrot parroting black is beautiful black is
beautiful
owls sending out whooooo's making love ...
and me and you just sitting in the sun trying
to find a way to get a banana tree from one of the
monkeys
koala bears in the trees laughing at our
listlessness

ever think its possible
for us to be
happy

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LIST OF ABBREVIATIONS AND ACRONYMS

COVID-19	Coronavirus disease, an infectious disease caused by the SARS-CoV-2 virus
E2SFCA	Enhanced Two-Step Floating Catchment Area

INTRODUCTION

This research stems from a curiosity about urban nature, public spaces, and those who live in cities. As such, within the umbrella of Urban Studies, the following dissertation concerns urban parks and those who use them. Parks are important places for human well-being and an urban ecosystem's health (A. Lee and Maheswaran 2011; Reyes-Riveros et al. 2021). They provide places within an urbanscape for respite, physical activity, and social connection (Chiesura 2004). They also provide irrigation, biodiversity, and heat relief that not only benefit the urban infrastructure and residents alike (Vieira et al. 2018).

Given these benefits, it can be said that parks have become an attractive addition to urban entities; however, there have also been negatives that arise from creating new or beautifying existing parks (Mullenbach, Baker, and Mowen 2021). Notably, the building of green spaces for tourism or financial uses that drive up private green spaces results in green gentrification and the displacement of residents. It is important to note that this dissertation does not center on gentrification. However, it is in the backdrop as we will be focusing on equity, i.e. the proximity and the crowding of these park spaces often as a result of land competition and development (Rigolon and Collins 2023; Mullenbach, Baker, and Mowen 2021; Anguelovski et al. 2018; Sister, Wolch, and Wilson 2010). These studies provide insight into the overall planning and the importance of parks with the acknowledgment that these ideas may lead to displacement.

The United Nations predicts that 68% of the world's population will be living in urban areas by 2050 (2018). Parks studies have focused on accessibility, primarily in terms of environmental injustices and inequities in terms of parks. The COVID-19 pandemic provided an important element sparking a lot of conversations surrounding park crowding, social distancing, access to parks, and, in general, the lack of parks in urban areas, all of which found their way to mainstream media (Ferah 2020; Goudreault 2020; Jobin 2020). All of this exacerbated the already established conversation about the park's need for those who need it. Park equity sets out to provide higher park provision than other groups for those with higher park needs, i.e., low-income, ethnic minority people, young people, and those who live in the urban core of cities (Rigolon, Browning, and Jennings 2018).

Park studies focus on accessibility, yet there are research gaps concerning crowding and design of different park types, which can be bridged with the use of fine-grain data. This study's scientific relevance is twofold. First, it expands upon the notion of accessibility by considering crowding through park areas and park equipment. Second, it puts forth two different data collection methodologies to expand on analyzing crowding in different park contexts. This is a funnel study, meaning that it starts largely in the Greater Montreal area and focuses or pinpoints local neighborhood parks. The focus is on enlarging the idea of accessibility to include aspects of crowding (either for park acres per inhabitant or equipment, further referred to as facilities per inhabitant). It takes a spatial view of accessibility in a large Canadian metropolitan area and then delves into six neighborhood parks to examine park use and perception of crowding.

Despite certain concerns over a multi-method case study being too localized or pertaining to too many methods, the study is replicable and can be used in many different contexts. The benefits as such can provide a snapshot of park use in a large metropolitan area and put forth a holistic approach to capturing each step of a subsequential study. A number of professionals can benefit from these research insights, from landscape architects to planners, politicians, and residents advocating for park design.

This study claims differences between the urban core and suburban parks in terms of park access levels, park use, and park quality. While certain parks, and within those parks, certain facilities are overused, the majority of the park landscape in Greater Montreal is underutilized. The aims of this paper are three-fold. First, to assess accessibility to parks across Greater Montreal's population groups (low-income, visible minorities, children, seniors) in an environmental equity analysis of social context and park size and equipment carrying capacity. Second, to examine park crowding in the function of park profiles and use. Lastly, it will analyze how visitor behavior affects visits. As a result, the main objective of this paper answers: "To what extent does the relationship between park quality and park usage differ across levels of park access in Greater Montreal?".

The following dissertation starts with Chapter 1, which consists of a literature review on cities, parks, and people. It focuses on the roles of parks, the funding, planning, and design implications of parks, and the research gaps in equity, accessibility, and park use knowledge. This chapter also highlights the theoretical and conceptual framework that leads this research, mainly topics of Environmental Justice, environmental equity, park perception, and the dimensions of density and crowding for park accessibility. Chapter 2 then lays out the research methodology. Each sub-question above is the subject of one methodology that builds on the others. Therefore, Chapter 2 highlights each sub-question and the methodology designed to answer these questions. The larger aspect of the research setting is also discussed in this chapter. Chapters 3, 4, and 5 present results to answer each sub-question. Chapter 6 returns to the main research aims and discusses how this dissertation's results fit into the larger field of park studies and the contributions it brings regarding the research gaps set out in the beginning. Chapter 7 concludes the dissertation and highlights the limitations and future research stemming from it.

PART I: CITIES, PARKS, AND PEOPLE

CHAPTER 1: LITERATURE REVIEW AND PROJECT FRAMEWORKS

This first chapter explores the intersection of literature on urban parks (benefits, design, and use) and people. It begins with a presentation of the role of parks as vital urban infrastructure. It examines the physical and mental health benefits, social advantages for urban residents, and ecological impacts of parks on the city ecosystem. This section solidifies the importance of public parks in cities, especially after insights from COVID-19. The second section addresses literature on equity in accessing parks and quality, while the third section focuses on the design implications of parks, particularly funding, planning, and design. Once viewed holistically, each of these subjects impacts each other throughout time, influencing the state of parks today.

Sections four, five, and six of the chapter establish the knowledge gaps, research questions, and dissertation conceptualization, respectively. As outlined in section four, this dissertation contributes essential elements to address the gaps in urban park studies on environmental equity and the nuance of park accessibility. Section five presents the research questions. Then, the sixth section delves into the theoretical and conceptual basis of the dissertation. Moreover, it covers the origin of the Environmental Justice movement and issues of environmental equity concerning access to parks, mainly when measuring park accessibility. It also examines how perception is crucial in park use, changing according to facilities, socio-demographics, and accessibility. Lastly, the conceptualization schema of the project is presented after discussing the carrying capacity and functional density dimensions. The following literature review places this research within the field of Urban Studies as it relates to cities, parks, and people.

1.1 Roles of parks for cities

In a broad sense, it has been argued that the landscape, especially parks, has been used to address and fix social problems (Loughran 2020). For example, environmental problems were highlighted as stressors for several diseases and epidemics in the 19th century (Y. Xing and Brimblecombe 2020). Therefore, during this time, parks were created as an antidote to the ills of industrialization, mainly to provide respite from pollution and odors for the working class, as wealthy families could live in the countryside. From then on, European parks influenced the design and creation of North American parks, particularly on the Eastern coast, under similar industrialization effects (Y. Xing and Brimblecombe 2020). Given the rising urbanization rates and urban land competition, there have been questions about the future of parks in cities (Greenberg 2015; Rigolon and Collins 2023). Currently, city governments, urban planners, public health agencies, and researchers increasingly focus on providing and improving park access due to the range of ecological and health benefits for cities (World Health Organization 2020; Tzoulas et al. 2007; Giles-Corti et al. 2016).

This dissertation defines “the park” as outlined by Kim et al. (2020). They define urban parks as “a place containing delineated open space including grounds and green spaces reserved for public use located in areas of high population density within a built environment” (2020, 107). For this dissertation, various park installations and facilities, such as playgrounds, are also included. The following five sections cover the various benefits of these spaces and the renewed interest in urban parks after COVID-19.

1.1.1 Physical health benefits

Numerous studies show that parks provide a place for physical activity for people of all ages (Arnberger et al. 2017; Bedimo-Rung, Mowen, and Cohen 2005; Cohen et al. 2010; Cutts et al. 2009; Klinenberg 2018; Maroko et al. 2009; McCormack et al. 2010; Ries et al. 2009). Parks offer a location for regular physical exercise (Cohen et al. 2010; Dahmann et al. 2010) and significant places of shade that provide relief from heat for seniors, as shown in Vienna, Austria (Arnberger et al. 2017).

Since recreation opportunities are mainly present in parks and people tend to walk to parks, an association exists between the proximity to parks and increases in physical activity (due to both walking to parks and exercising within parks). In Phoenix, Arizona, Cutts et al. (2009) set out to test the relationship between walkability to parks and obesity risks. The authors conclude that parks are an essential key to encouraging physical activity, and these results are further corroborated in other locations. For example, in Boston, Cradock et al. (2005) base their research on the assumption that increases in children’s and teenagers’ physical activity are heavily influenced by physical activity sites or playgrounds. It was found that youth physical activity is more likely to occur when nearby play sites are safe and well-maintained. Moreover, Rung et al. (2011) utilize “energy expenditure” measures to determine the most active park activities in five neighborhood parks in New Orleans. They find that basketball courts have the highest total energy expenditure, and playgrounds have the highest mean expenditure (Rung et al. 2011). This means both basketball courts and playgrounds are spaces with increased physical activity. Similarly, both Klinenberg (2018) and Maroko et al. (2009) conclude that different equipment can encourage physical activity and contribute to lower rates of cardiovascular disease, diabetes, and obesity. The presence of equipment is, hence, central to understanding physical activity in parks.

Nonetheless, several studies focus on the varying physical activity levels due to park equipment. In New York City, Maroko et al. (2009) examined the relationship between park acreage and the number of activity sites to calculate the equipment density. In particular, they mention the need for more senior-oriented equipment as most parks have equipment that older adults will be less likely to use, especially in more sports-oriented parks (Maroko et al. 2009). This study, however, did not survey the variety or diversity of park equipment installations. After addressing children's physical activity in playgrounds, Klinenberg (2018) raises the need to create suitable spaces and equipment for senior park users to increase their park use and physical activity. The author then examines different conceptions of "playgrounds for seniors" (p. 138) in Finland, China, the United Kingdom, and Spain. Furthermore, teenagers and young adults are missing targeted park facilities. Some studies show that adolescents' physical activity tends to decrease due to parents' restriction, increasing screen time, and ill-adapted park facilities for their age group (Carver et al. 2010; Van Hecke, Ghekiere, Van Cauwenberg, et al. 2018; Akpınar 2020). However, the need for welcoming park spaces is still very present (Akpınar 2020; Rivera et al. 2021). Increasing physical activity of all ages with park space and equipment also helps lower health risks and promote exercise and play.

1.1.2 Mental health benefits

The positive impacts of parks on mental health derive from a more extensive discussion of the positive influence of nature. Still to this day, there are inconsistencies with the measures of exposure to or the definition of nature (Hartig et al. 2014; Jimenez et al. 2021) and most exposure to nature studies have not sufficiently addressed sex and gender (Fernández Núñez et al. 2022), however, recent literature reviews do overall present positive mental health benefits (Jimenez et al. 2021; Lackey et al. 2021). When discussing parks and mental health, the link with nature is often made because parks provide this aspect of nature in cities, offering respite and lowering stress, especially for individuals living in urban areas (Arnberger et al. 2017; Arnberger and Eder 2015; Gilliland et al. 2006; Peschardt, Schipperijn, and Stigsdotter 2012; van den Berg, Hartig, and Staats 2007). Therefore, certain studies focus on access to nature via city parks (Bjerke et al. 2006), and others focus on the role parks play in stress relief

(Nordh, Alalouch, and Hartig 2011; Peschardt and Stigsdotter 2013). For example, Chiesura (2004) reviews the impact of parks on the quality of life in Amsterdam and highlights the social and psychological benefits of time spent in city parks. Chiesura (2004) finds that time spent in parks results in positively influences emotions and feelings. Studies on mental health particularly cite the role of parks in stress reduction, self-reported good health, relaxation, and lowered aggression (Conway 2000; Godbey and Mowen 2010; Hartig, Mang, and Evans 1991; Kaplan 1995).

Studies have also shown that park visits positively impact the mental health of younger and older visitors (Jenkins et al. 2015; Klinenberg 2018; Lambert et al. 2019; Nordh, Alalouch, and Hartig 2011). In Vienna, Austria, Arnberger and Eder (2015) compared park users' preferences when they sought stress relief versus when they were generally visiting. They found that green space preferences are similar when people seek stress relief or general recreation, but a less crowded park is more important for those searching for stress relief (Arnberger and Eder 2015). These characteristics will be further discussed in the section on park perception, as these sentiments can be experienced differently.

1.1.3 Social benefits

Parks provide multiple social benefits to individuals and communities by gathering people and being a place of social interaction (Chiesura 2004; Klinenberg 2018; S. Moore et al. 2010). More specifically, park gatherings promote intergenerational interaction and general community connection through sports and cultural event organization (Cohen et al. 2010; S. Moore et al. 2010; Pérez del Pulgar, Anguelovski, and Connolly 2020). Studies highlight the variety of interactions, ranging from a place of friendly meet-ups to a place for simple interactions between park users (Kim, Lopez Frias, and Dattilo 2020; Klinenberg 2018; van Aalst and Brands 2020; Wang, Brown, and Liu 2015). A study of particular interest by Van Aalst and Brands (2020) touches upon the differences between interaction and connection within park settings. Their research on park gatherings demonstrates that different user groups in Utrecht, the Netherlands, tend to have little interaction. However, the presence of others at the park (connection) was essential to the park's attractiveness. This denotes the various ways parks can influence a person's social health. Users can go to parks to meet up with friends, family, and team members, but the presence of others in a park can also provide a meaningful connection.

1.1.4 Ecological benefits

The ecological benefits provided by parks are related to the city's infrastructure and ecosystem. These benefits range from biodiversity, mitigating stormwater, and moderating the harms of heat waves, and are often associated with the type and abundance of vegetation found in the park (Vieira et al. 2018; Shao and Kim 2022; F. Zhang and Qian 2024). In terms of addressing different environmental risks in the face of climate change, parks can mitigate air and noise pollution, collect and regulate storm run-off, as well as sequester CO_2 in urban areas (Akbari 2002; McPherson et al. 2005; Nowak, Crane, and Stevens 2006; Oke et al. 1989; Whitford, Ennos, and Handley 2001). Parks aid in moderating the harms of heat waves by providing shade and regulating urban temperature (A. Lee and Maheswaran 2011; Vieira et al. 2018). However, as mentioned above, the type of and amount of vegetation matters for climate regulations. Vieira et al. (2018) highlight that layers of trees and shrubs are often better at purifying air and regulating temperatures than parks with just grass lawns. Xing and Brimblecombe (2020) further state that the spatial scale of parks also matters for air purification, concluding that small pocket parks with trees may not majorly impact city-wide air purification. Nonetheless, research has shown that diverse natural environments can impact heat within city blocks (Gao et al. 2022), which is beneficial not only to urban infrastructure but to urban residents as well.

1.1.5 Reflections from COVID-19

COVID-19 played a vital role in the analysis of public spaces and green infrastructure. While this dissertation is not about COVID-19, it is necessary to address the impact of the pandemic on park use and accessibility. The World Health Organization declared COVID-19 a pandemic on March 11, 2020 (WHO, n.d.). Due to the nature of the virus, global lockdowns took place in different spectrums of severeness. As a result, many countries had an array of lockdown measures with residents staying at home, increased remote work and school, and closed non-essential businesses (Honey-Rosés et al. 2020). The propagation of the virus, at first, led many governments to close down indoor gathering places, and some countries closed many public spaces, such as parks, to inhibit the propagation of COVID-19 (Heckert and Bristowe 2021; Bristowe and Heckert 2023). The closure of indoor spaces brought the importance of outdoor spaces in countries where parks were still open (Heckert and Bristowe 2021).

Remarkably, given the benefits previously mentioned, the pandemic underscores the importance of such places on the local and neighborhood scale (Honey-Rosés et al. 2020). In a time when movement was restricted, and physical activity declined (S. A. Moore et al. 2020), these benefits were highlighted for those living close to the park (Mitra et al. 2020). This brought to light in a very evident manner the importance of big enough spaces to maintain residents and social distancing. Parks became places where individuals exercised, played, relaxed, were in nature, and in community (Heckert and Bristowe 2021; Bristowe and Heckert 2023).

In Canada, federal, provincial, and local governments provided different lockdown regulations. In Montreal, between 2020 and 2021, regulations restricting movement were enacted alongside the rest of the world to curb COVID-19 (Honey-Rosés et al. 2020; Mitra et al. 2020; 2020). There were decisions to close certain park features at the beginning of the pandemic to diminish park use, but once these decisions were loosened, many Greater Montreal area parks saw an intense resurgence of park use overtime during all seasons (Corriveau 2020; Ferah 2020; Jobin 2020; Ruel-Manseau 2020). Since then, Montreal parks, similar to many cities around the world, have become important places where the accessibility and quality standards could be tested in a time when movement was restricted, and social distancing remained mandatory until at least the end of 2021 in Montreal.

Heckert and Bristowe (2021) review the literature on COVID-19's impacts on park use and visit frequency. They present several conclusions on how often trips to different types of green infrastructure and the characteristics of park visits changed. Trips to local parks increased, as did the consideration of crowdedness when choosing to visit a park (Heckert and Bristowe 2021). Furthermore, the frequency and time in which park visitors were at the park changed. For example, Derks et al. (2020) saw that temporal patterns no longer drastically changed between weekdays and weekends in Bonn, Germany. Both Derks et al. (2020) and Venter et al. (2020) saw park visits spread throughout the day and no longer saw peak visits before or after work hours. People generally spent more time in parks, which seemed less crowded as visits were not right before or after working hours (Venter et al. 2020; Herman and Drozda 2021; Weinbrenner et al. 2021). They also found increased rates of women, parents of young children, and larger households in parks (Heckert and Bristowe 2021).

Before the pandemic, research addressed crowding impacting of mental and social health (Sharp, Sharp, and Miller 2015; Arnberger 2012; Cohen et al. 2010). Discussions on crowding were then brought to the forefront during the pandemic. Individuals living in denser areas where parks' carrying capacities are surcharged meant that people might choose not to visit the park, despite being the ones that need it the most without lawns and personal green spaces. Regarding crowding, Heckert and Bristowe (2021) find that parks allowing for social distancing were due to either low crowding or having a large enough open space where distancing could occur. These inequities were found in cities in neighborhoods where yards are few and park hectares are scarce amongst the number of residents (Heckert and Bristowe

2021). This also highlighted the access and quality inequalities for several people since neighborhoods and residents had no access to greenspace and very little or crowded green space during a time when access to parks was even more demonstratively critical.

The pandemic underscored the importance of green space, particularly quality greenspace, that addresses the needs of those living around and being able to host different activities and age groups (Heckert and Bristowe 2021). Furthermore, the addition of travel highlights the need for local quality parks, as during the pandemic, some individuals could not travel to less crowded or more rural areas for recreation due to movement restrictions and public transportation. For example, the city of Montreal stated that a high increase in park use due to the pandemic led to increased park degradation (Goudreault 2020). Another example would be park users' comments on being unable to comfortably enjoy their park visit due to higher park user numbers that impede social distancing regulations (Champagne and Ferah 2020; Honey-Rosés et al. 2020). Furthermore, the city noted that some parks are used more than others, and a lack of equity exists due to a shortage of park access between neighborhoods (Goudreault 2020). These may lead to further inequities with differences in park size, maintenance, and presence between low-income and wealthier neighborhoods, as well as suburban and urban core neighborhoods.

1.2 Equity in accessing parks of quality

The general notion of accessibility addresses the “ease with which a site or service may be reached” (Nicholls 2001) and is often used when discussing urban parks. In park studies, sometimes accessibility is interchangeable with park proximity, however, studies have since shown that proximity is not the only factor that predicts park use (Park 2017). Park's definition for their systematic literature review define park accessibility combining physical and psychological accessibility integrated in one conceptual framework (2017). This particular definition of park accessibility allows for the evaluation of park equity in assessing parks of quality, as accessibility in this case is larger than only proximity.

It is also important to discuss the concept of park quality and its complicated measurement in research. First, park quality determinates are shown to be either through park characteristics and facilities (which also compromises their aesthetic and maintenance), as well as users' perceptions. In the past, a lot of the park quality assessments have focused simultaneously focused on the physical activity levels and the importance of quality over distance (Kabisch and Haase 2014; Shuolei Chen et al. 2020). However, a shift in research has led to using direct-observation methods to bring out how park facilities, amenities and aesthetics are important to measuring park quality (Shuolei Chen et al. 2020). In terms of assessing park quality, Chen et al.'s (2020) systematic review of non-spatial park dimensions, highlight that many cases park quality determinants such as park facilities and characteristics are categorized differently and are evaluated differently. Nonetheless, the authors recommend combining both park characteristics and users' perception, and surrounding area, as well as branching out from physical activity assessments to include other activities, within an assessment of park quality.

Therefore, the pursuit of park equity has a goal "that people with higher park needs- including low-income, ethnic minority people, and young people—have a higher provision of parks than other groups" (Rigolon, Browning, and Jennings 2018, 157). It is important to note that previous research acknowledges that disparities exist generally in park accessibility and particularly in parks of good quality. Therefore, while populations with high park-access needs may live in proximity to parks, the quality of their parks varies in terms of maintenance, park acreage, number of equipment installations, or higher potential crowding (Boone et al. 2009; Byrne and Wolch 2009; Honey-Rosés et al. 2020; Loukaitou-Sideris and Stieglitz 2002; Sister, Wolch, and Wilson 2010; Smoyer-Tomic, Hewko, and Hodgson 2004). Consequently, for inhabitants to benefit from living close to a park, it is crucial to provide parks of quality that are accessible in terms of proximity and non-proximity characteristics.

In the last two decades, environmental equity studies on the distribution of and accessibility to parks have been burgeoning. Many studies focus on the situation of ethnic groups and low-income populations to verify if they live in areas with lower levels of park accessibility in comparison to either high-income or predominantly white areas (Cutts et al. 2009; Maroko et al. 2009; Abercrombie et al. 2008; Boone et al. 2009; Cradock et al. 2005; Dahmann et al. 2010; Sister, Wolch, and Wilson 2010; Wolch, Wilson, and Fehrenbach 2005; Gilliland et al. 2006; Smoyer-Tomic, Hewko, and Hodgson 2004; Talen 1997; Talen and Anselin 1998; Apparicio et al. 2010). North American parks have been studied in different cities, such as Baltimore (Boone et al. 2009), Los Angeles (Sister, Wolch, and Wilson 2010; Wolch, Wilson, and Fehrenbach 2005), Montreal (Apparicio et al. 2010), Edmonton (Smoyer-Tomic, Hewko, and Hodgson 2004), and London, Ontario (Gilliland et al. 2006). Yet these studies often point to contradictory findings, depending on the study area and population groups examined.

Some authors found that areas inhabited by predominately white and high or mid-income populations have better proximity to parks, e.g., in Atlanta (Dai 2011), Denver (Rigolon and Flohr 2014), and Boston (Cradock et al. 2005). In contrast, other studies show Latinx populations live closer to parks in New York City (Miyake et al. 2010) and African American populations live closer to parks in both Baltimore (Boone et al. 2009), and Los Angeles (Wolch, Wilson, and Fehrenbach 2005). Other research shows that Latinx and African American populations live closer to parks in Phoenix (Cutts et al. 2009) and Hall County, Georgia (Johnson-Gaither 2011). Lastly, studies found that low-income individuals live closer to parks in Baltimore (Boone et al. 2009), Bryan, Texas (Nicholls 2001), Edmonton (Smoyer-Tomic, Hewko, and Hodgson 2004), and Los Angeles (Wolch, Wilson, and Fehrenbach 2005). Such contradiction is likely due to each city’s complex history of housing segregation, budget allocation for parks, and local governments’ capacity (Boulton, Dedekorkut-Howes, and Byrne 2018).

1.3 Funding, planning, and design implications

There are multiple factors shaping parks’ characteristics, including park funding, governance, design, and planning. Of important note is that there have been calls for involving community members and residents in the planning and designing of parks, as well as to investigate the policy aspect of park funding, participatory and interactional justice, and the role of nonprofit organizations in park policies (Byrne and Wolch 2009; Boulton, Dedekorkut-Howes, and Byrne 2018; Loughran 2020; Loukaitou-Sideris and Mukhija 2020; Anguelovski et al. 2022). The following sections present the literature on park funding and planning; more particularly, they report the changes over time that impact decision-making and park design.

1.3.1 Park funding and governance

The governance of urban parks varies by location. Often, studies have addressed this discrepancy in the hindering of park finance, park decision-making, and the achievement of justice through park equity. While many stakeholders are involved in a park's presence, a significant shift recently occurred in park governance. Park governance has shifted from public agencies to non-governmental organizations (NGOs), such as nonprofits and organized volunteer groups, in improving and maintaining park areas as well as calling for justice in park provisioning (Boulton, Dedekorkut-Howes, and Byrne 2018; Joassart-Marcelli, Wolch, and Salim 2011; Loukaitou-Sideris and Mukhija 2020; Anguelovski 2015; Rigolon and Gibson 2021). This, in turn, affects local decision-making for parks and funding. For example, Dahmann et al. (2010) demonstrate that more than half of the physical activities are organized in public parks but vary across Los Angeles municipalities regarding funding and frequency.

Park conception, planning, and development can impact the perception and use of parks (Byrne and Wolch 2009). Several studies on parks have investigated the policy aspect of park funding, justice in the planning process, and the role of nonprofit organizations in park policies. More specifically, studies on park financing have demonstrated the role of public policy and financing on park distribution (Ngom, Gosselin, and Blais 2016; Rigolon, Browning, and Jennings 2018; Wolch, Wilson, and Fehrenbach 2005). Wolch et al. (2005) concluded that variations in public funding of Los Angeles parks often widened existing inequalities. This has implications for future park planning to achieve park equity in Los Angeles and different cities. As Rigolon et al. (2018) note, there is an increase in different funding schemes to assure park equity, such as competitive grants that can be found in Canada.

Several studies also focus specifically on NGOs and their work on parks. Loukaitou-Sideris and Mukhija (2020) write of promotors' (community ambassadors) influence in increasing participation in park programs and park use by Latino, Asian American, and low-income residents living in the neighborhood around a Los Angeles park. In another study, Rigolon and Gibson provide a discussion between scholars' debate over the role of NGOs in assuring park equity. While some authors argue that NGOs may lead to cuts in green space spending (Apostolopoulou et al. 2014; Joassart-Marcelli, Wolch, and Salim 2011; Perkins 2013), others found that funding plays a role in the tasks of environmental justice NGOs. For example, Anguelovski (2015) and Fernandez (2018) found that NGOs can improve green space planning procedures but still have limited impact on the provision of parks due to financial costs. As a result, park funding and governance have implications for park equity.

1.2.2 Park design and planning

The evolution of parks can shed light on contemporary issues. Loughran (2020) argues that each era of development is associated with different social problems, from epidemics to residential planning or access to nature in an industrialized setting (Loughran 2020). Not only does park design change over time, but these changes also reflect evolving recreational ideals (Cranz 1982; Gold 1972; de Laplante 1990). American parks saw increased recreational facilities during the 1930s, where physical activities preceded former views of leisure and rest (Cranz 1982; de Laplante 1990). However, some would argue that a certain standardization of park design has been instilled in North American parks from the 1940s onwards by accommodating solely physical activities, which has left a void in contemporary park design to address the needs of diverse residents and activities (Cranz 1982; Loukaitou-Sideris 1995). City parks are often associated with sports fields, but they are much more than just areas for exercise. This association began to be prevalent after 1940, though sports fields are only one component of parks and not the largest (de Laplante 1990).

As a result, this historical aspect of parks encompasses park design quite well. Park design takes into account park layout, vegetation, and types of facilities available. Historically, contemporary design has only focused on certain populations needs and there are calls to focus on the needs of serval population groups especially as park use diversifies and there are more groups sharing park space (Cranz 1982; Byrne 2012; Loukaitou-Sideris 1995; Loughran 2020; Mehta and Mahato 2020). Contemporary design has not focused on park layout within the park to accommodate several different groups, nor focused on the design needs of those who live around the parks, and lastly, facility design within the parks tends to this day to create spatial segregation within park space (Mehta and Mahato 2020).

Therefore, park facilities, vegetation, open space, and the overall park layout are all impacted by design (Ostermann 2010; Mehta and Mahato 2020; Marušić 2011; Goličnik and Ward Thompson 2010; van Aalst and Brands 2020; Giles-Corti et al. 2016; McCormack et al. 2010; Li and Yang 2021; Powers et al. 2022). Numerous studies have focused on the characteristics that increase park use in North America and Europe (Arnberger et al. 2017; Arnberger and Eder 2015; Ayala-Azcárraga, Diaz, and Zambrano 2019; Cohen et al. 2010; Kaczynski, Potwarka, and Saelens 2008; McCormack et al. 2010; Ries et al. 2009; Rung et al. 2011; Scott and Mowen 2010). Some studies, such as Ayala-Azcárraga et al. (2019), Kaczynski et al. (2008), and McCormack et al. (2010), investigate which characteristics out of multiple yield a more significant increase in park use. For example, Ayala-Azcárraga et al. (2019) found that park infrastructure, walking distance, and vegetation had varying impacts on park use and well-being. Variables in this study, such as the naturalness of a park, different types of infrastructure, and the presence of trees, had the most influence on parkgoers. The authors explain that these factors contribute to increased park visits due to a few reasons. The presence of park facilities can stimulate multiple park areas simultaneously, greater naturalness is often associated with greater psychological benefits, and shorter walking distances often lead to more frequent visits (Ayala-Azcárraga, Diaz, and Zambrano 2019).

When conceptualizing park use, Bedimo-Rung et al. (2005) highlight that it is both the park's environment and policy characteristics that influence the usage of parks. Two important dimensions, park features and neighborhood design, are included in this model (Bedimo-Rung et al., 2005). Therefore, broader implications on park distribution, such as where the park is situated and the planning policies that determine its infrastructure, impact park use. This can be seen in the recommendations to represent the adjacent neighborhood in park planning instead of treating users as a homogeneous group or providing cookie-cutter parks based on regional recommendations (Loukaitou-Sideris and Sideris 2009; Low, Taplin, and Scheld 2005; Mehta and Mahato 2020). These different needs also intersect as studies demonstrate that the potential park user pool is very little involved in planning, nor are their preferences included in designs (Mehta and Mahato 2020; Smiley et al. 2016). This is why Mehta and Mahato (2020) underscore the need for unique park designs that consider residents and neighborhood demographics in response to outdated conceptions of one-size-fits-all parks.

Furthermore, it raises the need to utilize tools to prevent discrimination and biases through well-designed parks and recreational programs. (Davis and Edge 2022; Harris, Rigolon, and Fernandez 2020). In a Chicago case study, Harris et al. (2020) showed that youth of color avoided or stopped using urban parks if they faced citizen-based policing (i.e., avoidance, profiling, or calling law enforcement) by white residents. The use of citizen-based policing resulted in limiting the youth's presence and activities in local parks and perpetuated the endurance of white space in a gentrifying Chicago neighborhood. Klinenberg (2018) recommends integrating more investment in social infrastructure, such as parks and features in parks, to promote physical activity, social development, and cross-cultural and intergenerational experiences.

1.4 Knowledge gaps

This dissertation aims to address several knowledge gaps. The first knowledge gap is related to indicators of park accessibility. The most used accessibility measure is the walking network distance to the nearest park (Abercrombie et al. 2008; Gilliland et al. 2006; Smoyer-Tomic, Hewko, and Hodgson 2004; Talen 1997; Talen and Anselin 1998). In that way, accessibility to parks is conceptualized as park proximity. However, other authors argue that analyses of park access should take into account other park characteristics, such as the area or facilities, as well as the population size living nearby since they can also influence park use (Maroko et al. 2009; S. Moore et al. 2010; Hughey et al. 2016). Recent studies have developed accessibility measures that integrate the supply (hectares or park facilities) or the potential demand (population surrounding the park) to assess the potential congestion of parks and better measure park access (Maroko et al. 2009; Boone et al. 2009; Sister, Wolch, and Wilson 2010; Smoyer-Tomic, Hewko, and Hodgson 2004; Kaczynski, Potwarka, and Saelens 2008; Mears et al. 2019; Nicholls 2001). However, these studies have not combined spatial proximity and potential congestion to provide a snapshot of accessibility.

The second gap is related to park design. Previous studies have explored park design in terms of size and facilities (e.g., number, type, and quality) and showed the number and type of facilities can increase park use (Li and Yang 2021; Coen and Ross 2006; Kaczynski, Potwarka, and Saelens 2008; McCormack et al. 2010; Rigolon, Browning, and Jennings 2018). Nonetheless, very few focus on how these design details correspond with the surrounding neighborhood. Factors such as the type of neighborhoods surrounding the parks (densely populated versus suburban), the number of potential users in the park's surrounding area, and the park's facilities are intricately woven into park planning and design; however, these factors are not always considered. Therefore, while park planning plays a huge role in these decisions, the actual design of the park can also be made to ensure parks respond to the needs of those living close by to provide the facilities preferred by nearby residents, thus increasing use (Mehta and Mahato 2020; Powers et al. 2022).

The third gap concerns the measurement of park crowding. Studies of park accessibility are abundant, primarily using GIS-based computations of spatial accessibility to parks and various spatial data sources such as street networks, park location, and census data (Smoyer-Tomic, Hewko, and Hodgson 2004; Gilliland et al. 2006; Dai 2011; Ngom, Gosselin, and Blais 2016; De Alvarenga, Apparicio, and Séguin 2018; Cohen et al. 2010; Sister, Wolch, and Wilson 2010). Yet, estimations on potential crowding are done by computing the park surface (and their equipment) per capita in a given radius surrounding a park. To our knowledge, this indicator of potential crowding of parks is not validated with user data on perception, even though crowding is a significant subjective factor influencing park use for both adolescents (Rivera et al. 2022) and seniors (Arnberger et al. 2017). Therefore, fine-grained data on frequency, duration, and perception of crowding is needed to examine the relationship between park usage and park configurations or layouts to determine crowding.

Lastly, neighborhood parks have not been compared in different urban contexts. Indeed, previous park accessibility and use studies were conducted in mid-sized cities and the urban core of metropolitan areas. In Canada, we can point to research in London, Ontario (Gilliland et al. 2006), Edmonton (Smoyer-Tomic, Hewko, and Hodgson 2004), and the City of Montreal (Reyes, Páez, and Morency 2014; Coen and Ross 2006; S. Moore et al. 2010). They find low spatial inequities in these areas, yet they find parks with inadequate facilities throughout these regions, which remained out of their research scope for these specific studies. These studies show the lack of attention to park quality and address that while there are no flagrant inequities, park quality varies.

Most of the cited studies are not from Canada. Studies in Canada focus on potential spatial accessibility but do not research park use, the perception of potential users, or crowding (Hewko, Smoyer-Tomic, and Hodgson 2002; Smoyer-Tomic, Hewko, and Hodgson 2004; Reyes, Páez, and Morency 2014; Apparicio et al. 2010; Gilliland et al. 2006). Since parks are important neighborhood resources for promoting public health, there is advocacy for greater quality parks in Canada (Ngom, Gosselin, and Blais 2016; Tucker, Gilliland, and Irwin 2007; Mitra et al. 2020; Gilliland et al. 2006; Coen and Ross 2006). Therefore, park research needs multi-methods research to couple the objective indicators and subjective perceptions of park quality. Using different methods that encompass park users and their perceptions would bring nuance to and enrich park use patterns research. To address these knowledge gaps in North American park literature, my doctoral research aims to determine the degree of park access inequity by proposing a more comprehensive conceptualization of park quality. This conceptualization considers, along with park proximity, measured park crowding, the influence of design, and perception of crowding.

1.5 Research question and objectives

The research will answer the following main question: “To what extent does the relationship between park quality and park usage differ across levels of park access in Greater Montreal?”

The following sub-questions will also be answered:

1) How does the accessibility to parks vary across different population groups (e.g., low-income, visible minorities, children, seniors) in Greater Montreal according to a park’s proximity and carrying capacity of park size/equipment

2) How does park crowding differ in the function of park profiles and usage patterns?

3) How do visitors' behavior influence the frequency of visits, duration, and perception of crowding in Greater Montreal parks?

1.6 Theoretical and conceptual framework

In this dissertation, I will use the Environmental Justice movement's cues and related studies to draw on the literature on park quality, usage, and perception to build my conceptual framework. Regarding environmental issues and park equity, this body of literature focuses on the “differential access to urban public facilities that privileges one group and disadvantages another” (Sister, Wolch, and Wilson 2010, 231). In addition, this literature tends to focus on the distribution of park space in cities and their potential spatial access for racial or ethnic minorities and populations with lower socio-economic statuses (Anguelovski et al. 2018; Schlosberg 2007; Sister, Wolch, and Wilson 2010). Discussions on the two other pillars of justice and their interaction are still overlooked compared to distributional justice. However, multiple facets of recognition justice are relevant to urban parks, such as the park needs of users, the attitudes toward parks, park design, and social exclusion (Kronenberg et al. 2020).

1.6.1 The origins of Environmental Justice

Studies on equity or environmental justice in accessing parks are part of a shift in the environmental justice literature that focuses on the distribution of environmental benefits instead of hazards (Holifield 2001; Taylor et al. 2007; Tooke, Klinkenber, and Coops 2010). Environmental justice takes form as both a social movement and a theory (Byrne, Wolch, and Zhang 2009) that acknowledges and challenges inequities among urban ethno-racial and socio-economic populations in accessing environmental benefits or in exposure to harms (Agyeman 2005; Byrne, Wolch, and Zhang 2009; Pellow 2000). The shift of environmental justice from activism to academia is often cited as rising from the expansion of movements within the United States in the 1980s (Taylor et al. 2007; Walker 2012). However, there have been fights for environmental justice throughout history, even if it is not under such a name (Agyeman 2009). The environmental justice movement was grounded in the idea of the distribution of unhealthy environmental landscapes within U.S. cities. It was later extended to the impacts of such distribution and marginalization in and outside of the U.S. (Taylor et al. 2007; Walker 2012).

Environmental justice movements and discourses have increased and expanded to continue to analyze and frame the injustices impacting marginalized populations (Agyeman 2009).

Environmental justice as a theory provides a theoretical background and often results in adapting these different views of justice to the demands of environmental justice movements (Schlosberg 2007). Schlosberg (2007) identifies three pillars of justice: distribution, recognition, and procedural. These pillars focus on equity (distribution), cultural and racial recognition, and justice through participation (procedural) (Loukaitou-Sideris and Mukhija 2020; Schlosberg 2007). Moreover, recognitional or interactional justice refers to user interactions and recognizing different users' values and needs in a just manner (Kronenberg et al. 2020; Low 2013). Within the movement, claims are made keeping in mind the present, the future, and the process in which things got to be the way they are (Walker 2012). Using parks as an example, Kronenberg et al. (2020) assert that multiple facets of recognition justice are relevant to urban parks, such as the park needs of users, the attitudes toward parks, park design, and social exclusion. Procedural justice, or participatory justice, refers to the inclusion of marginalized groups into decision-making (Kronenberg et al. 2020; Rigolon et al. 2019). It can impact both distributional and recognitional justice due to the implications on public policy, public space design, and park funding (Rigolon et al. 2019; Kronenberg et al. 2020). Yet, the different understandings of justice and injustice have rarely shown up in the literature on the environmental justice movement. Agyeman et al. (2016) note that recent trends have called upon using these different framings to highlight other demands (i.e., inclusivity and diversity in park planning, park funding, and park safety).

1.6.2 Environmental equity and park accessibility

The prevalent reliance on spatial proximity measures in environmental equity studies has been critiqued for its inadequacy in capturing the complexities of park accessibility. Creating other measures of park accessibility, such as integrating congestion, can reveal significant disparities in park quality and accessibility among different sociodemographic groups. These two topics within environmental equity and park accessibility are discussed below.

First, the sole use of spatial proximity measures in environmental equity studies has been the focus of criticism. Smoyer-Tomic, Hewko, and Hodgson (2004) discuss the importance of considering population density when providing equitable playground access to children, as they found a larger presence of environmental inequities when considering park quality over spatial accessibility in Edmonton. Therefore, incorporating congestion measures has improved the different approaches to park access. For example, three studies conducted in Baltimore (Boone et al. 2009) and in Los Angeles (Sister, Wolch, and Wilson 2010; Wolch, Wilson, and Fehrenbach 2005) found that high-income and predominantly white areas have access to potentially lower congested parks, while African Americans, Latinx, Asian Americans, and Pacific Islanders, in addition to low-income groups, live closer to parks but with higher levels of potential congestion (Sister, Wolch, and Wilson 2010; Boone et al. 2009; Wolch, Wilson, and Fehrenbach 2005).

Second, it is important to take into account park congestion because high levels of congestion can potentially reduce a park's attractiveness and generate an accelerated degradation of its facilities (Bedimo-Rung, Mowen, and Cohen 2005). The analysis of potential congestion is of particular interest in intra-metropolitan dynamics but has received less attention in park equity research. Studies have shown differences in terms of park congestion between inner-city neighborhoods and suburban areas, as demonstrated in other North American cities (Rigolon 2016). In denser areas, less park surface per inhabitant may result in surcharged parks that people might avoid either because of lessened personal comfort or accelerated degradation, although such public spaces are more important for those who do not have backyards or space for vegetation at home (Honey-Rosés et al. 2020; Rung et al. 2011). Inversely, parks in lower-density areas, namely in the suburbs, will be less likely to experience congestion as it means more park space per person (Sister, Wolch, and Wilson 2010). In the same regard, the diversity and the number of park facilities (hence park congestion levels) have also been shown to vary across racial and economic lines (Maroko et al. 2009; Mehta and Mahato 2020). This confirms the relevance of examining park congestion along sociodemographic variables.

1.6.3 Park quality

An abundant literature has shown that criteria such as the presence of certain features, their condition, or the perceived quality of both conditions and features explain an essential insight into park quality (Coen and Ross 2006; Ellaway et al. 2007; Joassart-Marcelli, Wolch, and Salim 2011; Loukaitou-Sideris and Stieglitz 2002; Mehta and Mahato 2020; Rigolon, Browning, and Jennings 2018; Smiley et al. 2016; Ostermann 2010; Pérez del Pulgar, Anguelovski, and Connolly 2020; Seeland, Dübendorfer, and Hansmann 2009; Tucker, Gilliland, and Irwin 2007; van Aalst and Brands 2020). For example, Cradock et al. (2005) shows that low-income young people in Boston, Massachusetts, have favorable proximity to parks but that these parks needed to be better maintained. Moreover, Coen and Ross (2006), in Montreal, Canada, highlight that the quality of parks varies between neighborhoods, given their health needs. The conditions of the park and differences in park location were lower in poor health areas despite parks being good resources for public health. Therefore, for parks to be good public health resources in poor health areas, park quality needs to be increased.

In a literature review of qualitative research related to park use by McCormack et al. (2010), the authors highlight that park conditions, namely poor conditions, can impede park use as they impact a park's condition, aesthetics, and safety. A review of 21 studies finds that maintaining parks is important for all ages and that cleanliness and safety can encourage park use. The upkeep and maintenance of parks are standard variables in park studies because parks with low upkeep may either discourage usage (Loukaitou-Sideris and Stieglitz 2002; Rigolon 2016; Rung et al. 2011; Slater et al. 2016) or inversely shine the light on a park that hosts many users (Groshong et al. 2020; Rung et al. 2011). Rung et al.'s study (2011) sought to determine the influence of park conditions and features on park use to rectify the absence of research on park infrastructure maintenance. Their findings conclude that some park conditions positively or negatively impact use. For example, they suggest that there is a minimal basis for basketball maintenance that attracts users; however, there is no correlation between use and maintenance after this baseline was attained (Rung et al. 2011). They also conclude that poor green spaces in parks were in line with a more significant number of users, therefore denoting the impact of increased usage on park conditions.

1.6.4 Perception of parks and crowding

Park use also depends on park perception, as an individual's perception of an area will encourage or discourage visiting certain parks. Park perception is, hence, essential in determining park use. Users' perceptions of park characteristics regarding distance, safety, or inclusiveness influence park use (Byrne and Wolch 2009). Studies on perceived accessibility focus on indicators outside the scope of realized accessibility and park proximity. Wang et al.'s (2015) research builds on the idea that perceived access to urban parks is influenced by physical and non-physical variables while focusing on larger social and cultural contexts of the urban setting. This latter part is not always discussed in studies on urban parks and accessibility. For example, Ries et al. (2009) conclude in their study that perceptions of greater park availability, rather than objective measures, increased physical activity. These findings are similar to those of Wang et al. (2015) in Brisbane, Australia, who concluded that perceived accessibility is more important than physical accessibility.

Byrne and Wolch (2009) propose a conceptual framework (Figure 1) that touches upon the different influences on perceptions that provide a potential user with park use choices. They argue that first, potential park users have different socio-demographic backgrounds, socio-economic statuses, location and mobility, time resources, attitudes to nature, and leisure preferences that influence their perception of tolerance, friendliness, exclusivity, danger, access, and costs of a park (Byrne and Wolch 2009). Second, they simultaneously argue that historical and cultural contexts of parks influence the park space (namely its physical characteristics, nearby neighborhoods, service provision costs, management philosophy, maintenance, and signage) and thus impact the same indicators of perception. Therefore, personal and structural conditions make up a person's perception of a park, which encourages or discourages a potential park user from using a park.

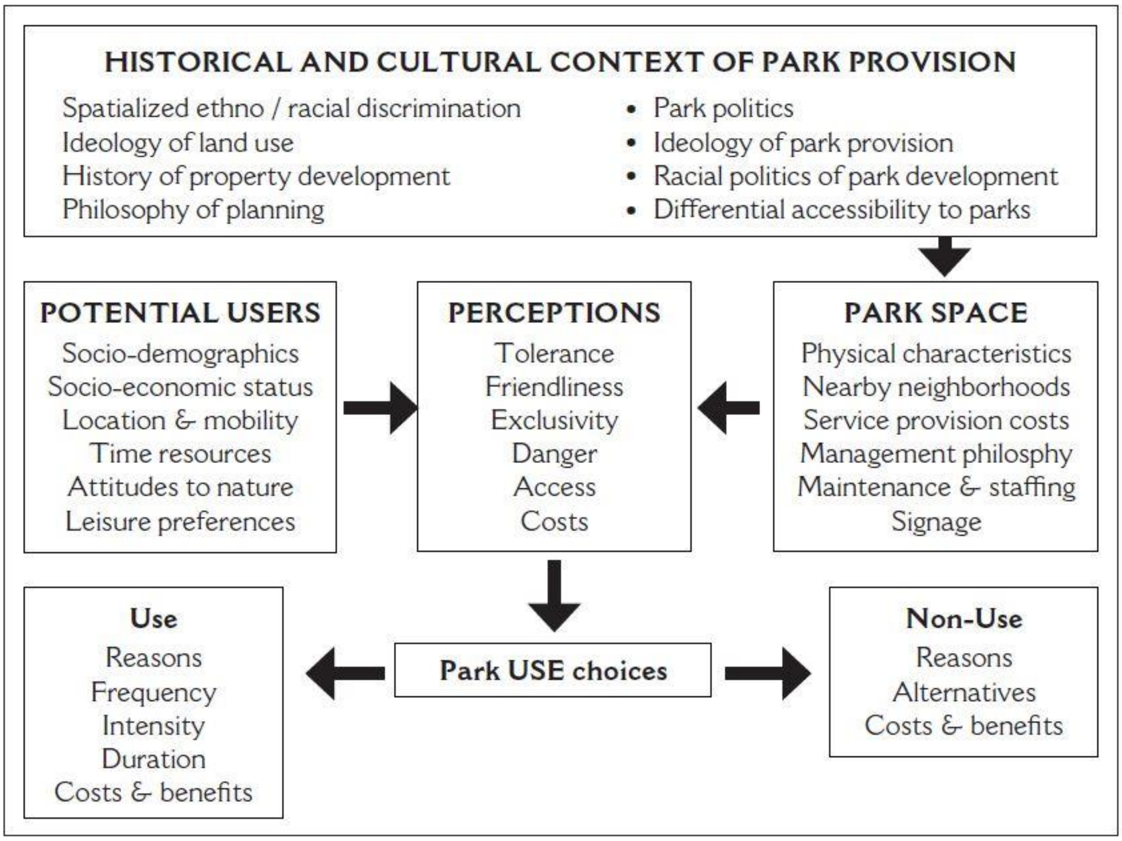

Figure 1. "Space, race and park use".

Conceptual framework on the importance of historical and cultural contexts in park provision and space (e.g., physical characteristics and nearby neighborhood). Source: Byrne and Wolch, 2009, p.751.

Different user groups have different perceptions of parks, which falls into the perception of inclusiveness. McCormack et al. (2010) underlined that social and physical environment perceptions cannot be separated. For example, competing park uses and values can be regarded simultaneously by two different people as threatening or enjoyable (Walker 2012). This means that the potential users' perception of a park's amenities or features influences park use and how these potential users benefit from parks. Due to these differences, additional research must be conducted on the park's capability to accommodate different user groups and users' perceptions of diverse distributions of either park activities or equipment (Mehta and Mahato 2020).

More specifically, previous studies have shown that a park will be visited if potential users perceive it as a safe and inclusive place. This means that even if a park is close in proximity, it is not guaranteed to be visited. In terms of safety, Groshong et al.'s (2020) qualitative study on perceived park safety looked at the interaction between user behavior, like violence, and park maintenance (i.e., lack of maintenance, lack of lighting, and traffic/busy roads) in low-income neighborhoods in Kansas City, Missouri. The authors conclude that the perception of safety is multidimensional as the indicators of perceived safety are intertwined with the different characteristics already discussed in this review. A park perceived as unsafe and poorly maintained will be less likely to be visited. Similarly, Mitra et al.'s (2014) study looks at how Torontonian parents' perception of neighborhood safety and sociality influences the individual freedom of their children. They find that children with greater independence have parents who perceive their neighborhood to be safer. Furthermore, they find that boys and older children are granted more independence than girls and younger children, confirming gendered aspects of mobility (Mitra et al. 2014). In the studies of Groshong et al. (2020) and Mitra et al. (2014), changes to neighborhood design, such as safe walkability and organized activities, are mentioned to influence park perception positively and, thus, park use.

Finally, other features can improve users' perception of a park. Bertram and Rehdanz (2015) acknowledge city-specific cultural activities related to tourism and recreation that influence the perception of parks in Berlin, Stockholm, Rotterdam, and Salzburg, especially for larger parks. They found that providing recreational services is essential in park perception for all four cities but that parks' tourism roles are crucial in only Stockholm and Salzburg. Bjerke et al. (2006), Buchel and Frantzeskaki (2015), and Campbell-Arvai (2019) study the perception of nature, vegetation, and biodiversity as influences for park visits in Norway, the Netherlands, and Canada, respectively. In each case, potential users regarded the preference for vegetation and biodiversity as necessary for aesthetic values, psychological benefits, and increasing quality of life. A positive perception of a park will increase the likelihood of coming to and using the park.

1.6.5 Park use

There are other aspects, such as peers and leisure, that have proven to improve perception, both of which are highlighted in Byrne and Wolch's (2009) framework and are detailed below.

1.6.5.1 The importance of peers for park use

Individuals have social networks that prove to be important in understanding park use since they can influence or discourage park use (Baur, Tynon, and Gómez 2013; Ries et al. 2009). Previous research suggests that adolescents' park use increases with the presence of social networks and peers (Van Hecke, Ghekiere, Veitch, et al. 2018; Fitzgerald, Fitzgerald, and Aherne 2012; Rivera et al. 2021). For example, Ries et al. (2009) look at a broader range of factors, such as the awareness of park availability, perception of park quality, and social networks that may increase park use for African American adolescents in Baltimore, Maryland. They note that park use would more likely increase if there were positive perceptions of park availability, quality, and use by friends. Yet the authors note that park quality may attract adolescents to facilities but does not impact their activity level, highlighting the need to study what constitutes park quality to promote park use.

Baur et al. (2013) discuss the impact of social networks on the attitudes of Portland nature parks' nonusers. In contrast to the other indications of park use, the authors found that park use was strongly linked to the perception of friends and family. Therefore, a person was less likely to visit if personal connections had negative experiences or perceptions of a particular park space (2013). Pérez del Pulgar et al. (2020) examine the influence of new play spaces and park vegetation on children's well-being in two neighborhoods with different social compositions in Barcelona, Spain. They conclude that social interactions and broader neighborhood contexts were more critical in determining park use than park spaces *per se*. More specifically, in the gentrifying neighborhood of Poble Nou, park visits to the isolated park were very individualized or family-oriented. However, in Nou Barris, a working-class neighborhood, the park was heavily used, promoted strong social ties, and place attachment for children and parents. As a result of these findings, research on increasing park use based on the intersectionality of park preferences and expectations is needed.

This goes with intergenerational dynamics as well. For example, Moore et al. (2010) show that in Montreal, Canada, if an older person lives in a younger neighborhood, they are less likely to visit. This is usually because the park does not have the infrastructure or a welcoming social environment. In contrast, older counterparts living in areas with higher age averages were more likely to use the closest park. This is in line with Ries et al.'s (2009) finding on social networks and park users: adolescents in Baltimore were more likely to use a park if friends were also using the park. Given both Ries et al. (2009) and Moore et al.'s (2010) conclusions, the influence of social networks in various age groups also impacts park use. In sum, studies on park users often advocate for diverse park features and the inclusion of personal conditions that may help attract more park users. This demonstrates that increasing park use differs from city to city and neighborhood, depending on the park users.

1.6.5.2 Temporal variations in park use

There are temporal aspects that influence park use and patterns observed through research: there are different users during different times of the day, on different days, and participating in different activities. Often, temporal research is separated between times of day: morning, afternoon, and evening, and by day: weekday and weekend. Overall, in Salt Lake County, Utah, Park et al. (2020) find that parks were most visited during the weekend (2.20 people/acre versus 1.4/acre on weekdays. When looking at temporal patterns and gender, they find male and female visitors were more often found in the park at noon and weekend afternoon; however, there were more females on weekday mornings and around noon (2020). As for differences in time, the late weekday afternoons saw more users (3.00 people/acre), and the early afternoon and weekend afternoons are the most popular time slot (5.41/acre and 4.47/acre, respectively) (2020). In Madrid, Spain, children were most often at the park during the weekend. However, all the other age groups were most observed during the weekdays, and the parks were used most during the afternoon and evening (Fontán-Vela et al. 2021).

As for temporal patterns in activities, Park et al. (2020) find that activities in open spaces, the playground, and skateboarding were the most popular activities during weekday afternoons and weekend afternoons. The authors note that the activities with the most differences in user densities during the day are picnic areas, playgrounds, soccer fields, and skateboarding. Moreover, Bertram et al. (2017) find that weekday park uses usually consisted of sports and transit, whereas, on the weekend, visitors partook in walking and spending time with friends and family. These activities had the most significant differences between weekdays and weekends. Fontán-Vela et al. (2021) found that park use observations were similar between weekdays and weekends in Madrid, Spain. However, the levels of physical activity changed drastically. The most rigorous physical activity was during the weekend (0.6% during the week compared to 11.7% on the weekend), while a medium type of physical activity was often observed during the week (Fontán-Vela et al. 2021).

Lastly, an important aspect of park use is the influence of leisure time on when and why people visit parks (Byrne 2012; Fontán-Vela et al. 2021). Byrne (2012) focuses on the constraints that influence leisure time, such as transportation, responsibilities, and work obligations, which only allow some visitors to visit during the weekend. This often resonates when addressing weekday versus weekend park use; research has shown that people are more willing to travel longer on the weekend to visit a park (Bertram et al. 2017). Therefore, on weekends, parks tend to become more crowded. Arnberger (2012) writes of work obligations that limit park visits to Sundays when park settings are often more crowded. This is backed up by research in

Phoenix, Arizona, as it was found that larger parks are most popular on Friday and into the weekend (Li and Yang 2021). Neighborhood parks are then the most visited during the week, and visits decline during the weekend (Li and Yang 2021). The same was found in Berlin (Bertram et al. 2017). Fontán-Vela et al. (2021) concluded that more comprehensive policies are needed to address this discrepancy in leisure time and not only focus on the presence of parks.

1.6.6 Influence of age and gender on park use

1.6.6.1 Young children and their caregivers

For young children, most studies focus on children’s play and their preferences. For example, in Salt Lake County, Utah, children and their adult guardians used playgrounds, soccer fields, and open spaces (Park, Christensen, and Lee 2020). Loukaitou-Sideris and Sideris (2009), in their study on children’s park use in urban core and suburban Los Angeles, found that children’s park preferences varied depending on age, ethnicity, and location. For example, park size and equipment were essential to both locations, however, park size was a little more significant to urban core children's park use. The children’s play hours were highly connected to the number of facilities and structures within the playground (Cohen et al. 2020).

Nonetheless, playgrounds are popular park installations promoting children’s play. For example, Cohen et al. (2020) focus on playground features that entice physical activity across age groups in 25 US cities. The parks studied have an average of 7.4 facilities. Playgrounds constituted 25% of children’s activity during their observation periods, and most children spend time in these areas (2020). Furthermore, children are the most observed age group in these park-use studies. In Nanchang, China, 76% of children (compared to 24.0% of teens) were observed in eight parks (J. B. Moore et al. 2017). Similarly, Baran et al. (2014) found that children 6 to 12 were the most observed age group in Durham, North Carolina.

As young children are often accompanied by adult caretakers, as depicted in Portland, Oregon (Talal and Santelmann 2021), some studies focus on parents’ perceptions of park preferences, proximity, safety, and its impact on children’s park use (Irwin et al. 2005; Tucker, Gilliland, and Irwin 2007). By looking at parents’ preferences for playgrounds, Tucker et al. (2007) found that swings, water games, and shade were features that led to more park visits from parents with children. Moreover, parents’ perceptions also impact children's mobility (Gilliland et al. 2006; Irwin et al. 2005), and studies have shown that caregivers are even willing to travel further away in search of specific park facilities (Flowers et al. 2020; Veitch et al. 2006; Tucker, Gilliland, and Irwin 2007).

1.6.6.2 Adolescents and young adults

Place, identity, and inclusion are important themes in park use studies for adolescents and young adults. Parks are significant for this age group, especially in urban spaces, as they allow for interactions and the expression of identity, and they have more autonomy than young children (Pham et al. 2019; Carver et al. 2010; Veitch et al. 2014). An important aspect of adolescent park visitation is the presence of peers (Van Hecke et al. 2016; Fitzgerald, Fitzgerald, and Aherne 2012; Ries et al. 2009; Rivera et al. 2021). In Melbourne, Australia, Rivera et al. (2021) find that spending time with friends was the most common reason to visit a park. In Zurich, Switzerland, Seeland et al. (2009) write that youth go to parks and playgrounds to play sports, mainly soccer; however, as park users age, there is more interest in meeting friends. Their study concludes that green spaces are the most important place for social inclusion, particularly in this study on making friends across cultures (Seeland, Dübendorfer, and Hansmann 2009). Nonetheless, research finds that teenagers are often unobserved in park settings (Park, Christensen, and Lee 2020; Mehta and Mahato 2020) due to parks' lack of infrastructure for this age group.

Research on adolescent and young adult park use focuses on better designing park space for this age group to increase use (Akpınar 2020; Rivera et al. 2021). Cohen et al. (2020) find that adolescents tend to have different preferences regarding facilities and activities than other age groups in various U.S. cities. Sports features were the most mentioned characteristics for both social and physical activity in Melbourne, Australia, for youth ages 13 to 18 (Rivera et al. 2022), in Belgium for youth 12 to 16 (Van Hecke, Ghekiere, Van Cauwenberg, et al. 2018), and in Copenhagen, Denmark (Lindberg and Schipperijn 2015). In Melbourne, Australia, Rivera (2022) find that walking/cycling paths, playgrounds, and open spaces were popular for active park use and sports facilities. They also note that picnic areas, sports features, seating, events, and shade are important features for social park use (2022). Moore et al. (2017), in an 8-park study in Nanchang, China, find that youth mostly partake in sedentary activities. They found that about 44.9% of all activities were sedentary, and walking activities accounted for 38.3% (2017, 257). Van Hecke et al.'s (2018) study on the province surrounding Brussels concludes that upkeep, the presence of playgrounds and outdoor fitness equipment, and sports fields are the three most preferred characteristics for both park visitation and physical activity.

Outside of park facilities, previous research found park maintenance to be favored by adolescents in Durham, North Carolina, Victoria, Australia; the province of Flemish-Brabant (Flanders), Melbourne, Australia; and Los Angeles (Baran et al. 2014; Veitch et al. 2016; Van Hecke, Ghekiere, Van Cauwenberg, et al. 2018; Rivera et al. 2022; Veitch et al. 2017; Loukaitou-Sideris and Sideris 2009). Some features can dissuade park use, Akpınar (2020) finds that for teens aged 13 to 19 in Aydin, Turkey, long distances and lack of green or unattractive green spaces were barriers to park use. The most significant takeaway from Akpınar's (2020) study was that the duration of physical activity and playground design for young children were negatively correlated. This means physical activity decreases when parks are designed more for young children (2020). In particular, while playgrounds were the most popular park facility used by children, adolescents often discussed their preference for playgrounds for both active and social activities. Still, they are rarely found on the playground (Baran et al. 2014).

This is usually because playgrounds are considered more appropriate for younger children. Rivera (2021) and Van Hecke (2018) both find that playgrounds are important features in adolescents' physical activity in parks if they are age-appropriate. Most often, playgrounds are not challenging or "teenager friendly," as Rivera (2021, 4) states in their study. For example, Van Hecke et al.'s (2018) study shows that playgrounds did not add to needs for park visitation; however, playgrounds play a prominent role in park use for adolescents who babysat younger siblings. This was also the case in another study in Brussels, Ghent, and Antwerp, Belgium (Van Hecke et al. 2016). In this study, parks with multiple facilities for different age groups were helpful for adolescents who babysat. In both studies, playgrounds that were more designed for younger children were not attractive to adolescents. However, when asked about playground preferences, adolescents in Melbourne, Australia, preferred slides and swings (Veitch et al. 2017). Despite playgrounds being a popular park facility, many playgrounds are not suited for adolescents, and the studies in this literature review could bring light onto more age-appropriate park facilities to increase park use for the adolescent age group.

1.6.6.3 Adults and Seniors

As mentioned before, studies have found that adult caretakers take part in more sedentary activities. In Cohen et al.'s U.S. study (2020), they write that the design of playgrounds is not meant for adults who bring children to the park to be active, and therefore, adults tend to be pretty sedentary at the park. For general adult park use, there is the same trend. Adults partake in sedentary activities or in other activities such as trails, sports fields, and pools in Durham, North Carolina, and Salt Lake County, Utah, respectively (Baran et al. 2014; Park, Christensen, and Lee 2020).

For older adults, alongside adolescents, research has shown that older adults are not highly observed in parks compared to other age groups (S. Moore et al. 2010; Park, Christensen, and Lee 2020; Mehta and Mahato 2020). Research on seniors' park use highlights the need for connection, accessibility, and leisure. Accessibility characteristics that increase park use are noted to be clear and navigable paths to the park or close public transportation stops, as well as diverse seating options (Gibson 2018; Veitch et al. 2022; Arnberger et al. 2017). Park features such as walking paths, shade, facilities, relaxing settings including trees, and other natural features were considered to increase park use in older adult studies in Melbourne, Australia, Vienna, Austria, Australia, and Britain (Veitch et al. 2022; Arnberger et al. 2017; Gibson 2018; Aspinall et al. 2010).

1.6.6.4 How does gender influence park use?

Gender proves to be an influencing factor in park use. For example, men and boys are more present than women and girls in Chicago parks (68.4% versus 31.6%) (Floyd et al. 2008), in Los Angeles parks (62% to 38%) (Cohen et al. 2007), and in Salt Lake County parks (1.56 male users/acre to 1.28 female users/acre) (Park, Christensen, and Lee 2020). Other studies also find that males of all ages dominate park use and engage in higher physical activity levels (Baran et al. 2014; Reed et al. 2008; Talal and Santelmann 2021). When observing eight Los Angeles neighborhood parks, Cohen et al. (2007) found equal numbers of men and women using playgrounds, jogging paths, and tennis courts. Still, drastic differences were found in organized and competitive sports in which men dominated the usage.

As for the playground, studies show that it is one of the most popular facilities, and gender differences vary. Park et al. (2020) find more male children and teenagers in the parks but more female adults on the playgrounds. This is also observed in Los Angeles (Cohen et al. 2007) and the U.S.-wide study (Cohen et al. 2020), where women are more present in parts of the park where children's supervision took part, such as the playground. Cohen et al. (2020) observed 84% more adult females at playgrounds than adult males, 56% more female teens, and 6.6.% female children. While males still outnumbered the females, they were found in places outside of the playground. However, Baran et al. (2014) found that playgrounds were popular with girls and boys in Durham, North Carolina.

When asked about playground and park features, studies have researched facilities that could increase park use. In the same Cohen et al. (2020) study, the authors conclude that climbing structures and crawling tubes were playground features liked by female and male visitors. Similar structures were preferred in Victoria, Australia (Veitch et al. 2016). Sports facilities are sought out by both male and female park users (Rivera et al. 2021), however, male park users are more often observed in these sport facilities, for example, in basketball courts (Baran et al. 2014; Park, Christensen, and Lee 2020). In Melbourne, Australia, adolescent females are more likely not to visit a park if the playground was designed for smaller children, if there is no playground, or if there are no swings (Rivera et al. 2021). The males in this study sought picnic areas for social interaction and sports facilities for physical activity (2021). In Victoria, Australia, Veitch et al. (2016) find that basketball courts were prevalent for male and female adolescents, while in Durham, North Carolina, basketball courts were used by male adults and teens (Baran et al. 2014). In Hanoi, Vietnam, Pham et al. (2019) found that male users visited parks more often and for longer. The authors also found that sports were the primary motivation for male park users; however, socializing was non-gendered. Adolescent males would likely only visit a park if there were sports facilities or goalposts. Similar findings were found in Baran et al. (2014), Loukaitou-Sideris and Sideris (2009), and Park et al. (2020).

Nonetheless, studies should not essentialize gender roles in park use (Loukaitou-Sideris and Stieglitz 2002), as it can be seen that girls’ park use is much lower than boys’. Therefore, research focuses on factors that may inhibit girls' park use, such as safety and lighting, and especially how to increase it (Talal and Santelmann 2021).

1.6.7 Dimensions of density and crowding for park accessibility

1.6.7.1 Parks' surrounding neighborhoods

A park's context can include the park's size, the surrounding social environment, and the built environment around the park. Park studies often explore various aspects of a park's context. However, research on distributional environmental justice typically focuses only on the social environment of a park. The broader context of the park, including the built environment and the interaction between the social and built environment, is rarely the central focus of such studies. Nonetheless, parks' contexts do matter for quality and use. For example, a park close to an industrial zone or heavy intersections compared to a park in a calm residential neighborhood will impact the quality of the park (Coen and Ross 2006; Cutts et al. 2009; S. Lee 2019). Moreover, the elements of the built environment can impact accessibility and human well-being (Hughey et al. 2016). These elements range from sidewalks and public transportation (Reyes, Páez, and Morency 2014; Scott and Mowen 2010) to population density and neighborhood age compositions influencing park usage (Maroko et al. 2009; S. Moore et al. 2010).

A park's context includes the potential park users with different preferences and needs. Studies have identified that the social composition surrounding parks may affect their quality and use, for instance, proximity to an individual's residence, school, or workplace (Adinolfi, Suárez-Cáceres, and Carinanos 2014; Coen and Ross 2006; Cutts et al. 2009; S. Lee 2019). For example, Adinolfi et al. (2014) conclude that parks close to educational institutions have increased visitors during after-school hours. In addition, Moore et al. (2010) concluded that seniors will be more willing to use a park if they believe the neighborhood is secure and accessible. Moreover, Maroko et al. (2009) find that the presence of one age group in a park may lead to the exclusion of another. They concluded that intense physical activities in parks may discourage park use by seniors.

Lee's (2019) research in Chicago, Illinois, represents a rare study in which a park's surrounding built environment is the subject. The Chicago Park District classifies public parks based on park size, park facilities, and the primary population served. However, Lee (2019) criticizes the single broad category into which neighborhood parks fall. The author classifies 150 neighborhood parks into six new categories based on the composition of the area. This alternative park typology places neighborhood parks based on their surrounding context to demonstrate varying types of neighborhood parks. These six categories are urban core commercial, less permeable low-density, neighborhood-scale commercial, walkable mixed-use, and bikeable multi-family (S. Lee 2019). The presence of parks in urban residential areas and others closer to industrial areas or downtown areas suggests that there are different types of users (S. Lee 2019). Lee's typology is based on park context; however, there has yet to be a discussion on the differences in quality and usage between the types of parks.

Furthermore, the population density of a park's context also provides insight into equitable park space distribution. The relationship between population density and park need is another reason a park's context matters. There is usually an understanding in research that urban core neighborhoods have a higher park need due to the lack of private open space, such as backyards that prevail in low-density residential areas (Gilliland et al. 2006; Loukaitou-Sideris and Stieglitz 2002; Mitra et al. 2020; Park, Christensen, and Lee 2020; Rigolon and Flohr 2014; Smoyer-Tomic, Hewko, and Hodgson 2004). A park's size is related to park crowding when looking at park area per resident (Maroko et al. 2009; Rigolon, Browning, and Jennings 2018). Therefore, population density impacts park distribution, residents' perception of that space, and park use. On the one hand, as urban cores become denser, there is a growing concern about the lack of park space or competing demands. (Arnberger 2012; Cohen et al. 2010; Greenberg 2015). On the other hand, several authors have noted the difference between the inner city and their suburban counterpart's park accessibility (De Alvarenga, Apparicio, and Séguin 2018; Gilliland et al. 2006; Honey-Rosés et al. 2020; Loukaitou-Sideris and Stieglitz 2002; Mitra et al. 2020; Timperio et al. 2007). They often emphasize that having access to private outdoor areas, such as backyards, can impact an individual's level of physical activity and provide a larger space to achieve the same benefits as a public park. For example, Maroko et al. (2009) state that public parks are crucial in areas where there are no to very few private green spaces. Loukaitou-Sideris and Stieglitz (2002) also note the different perceptions of park space between urban core and suburban areas, highlighting that park space in Los Angeles is more viewed by families in the suburbs as a weekend activity. Nonetheless, while a majority of studies (except Lee, 2019) do not solely focus on the park's context, it is evident that these dynamics are relevant as nearby residents are potential users.

1.6.7.2 Carrying capacity and functional density

Two concepts of park crowding, carrying capacity and functional density, are of importance park evaluation. Authors such as Cohen et al. (2010), Rung et al. (2011), Sister et al. (2010), and Whyte (1980) have addressed the importance of carrying capacity in assessing either park quality or public space quality and environmental equity. A park's carrying capacity is the number of people it can support before seeing signs of deterioration. In contrast, the park's functional density is the number of people that make a park visit enjoyable (Cohen et al. 2010). These concepts help evaluate the potential crowding or congestion of parks based on the population density they serve, both in terms of their size and equipment. It is important to understand that crowding can have positive and negative effects (van Aalst and Brands 2020; Van Hecke et al. 2016; Rivera et al. 2022; Cohen et al. 2010; Rung et al. 2011). Among these few studies that mention functional density and carrying capacity in urban neighborhood parks, Cohen et al. (2010) acknowledge that these under-researched concepts can help determine how well neighborhood parks operate.

With an analysis of park characteristics, interviews with park directors, and user observations, Cohen et al. (2010) conclude that only a few factors can explain why some parks are more populated. They found that park size and organized activities attract people to parks. Using the concepts of functional density and carrying capacity, the authors determine that parks are underutilized compared to people's physical activity needs. Following Cohen et al. (2010), Groshong et al. (2020) write that "interventions that attract more users to parks for physical activity would, in theory, contribute to a strong sense of functional density…" (p. 13). This means that there is a specific number of people in a park that provides the best park experience.

Some studies, similar to those of Groshong et al. (2020), consider the level of park crowding to be a dimension of park quality. Arnberger et al. (2017), studying seniors' park preferences in Vienna, Austria, conclude that parks must not be too crowded but not empty for optimal use, which is linked to functional density. Furthermore, Sharp et al. (2015) refer to place attachment and park visits; however, they are a study on a larger type of park (national park). In this study, place attachment is linked with the frequency of visits and activities in the park. In another study, Arnberger and Eder (2015) urge more discussion on park crowding as they conclude that park users seeking stress relief and those on general visits have similar preferences regarding the optimal level of crowdedness. This implies that other potential park users have opinions on crowding, though the research has not been conducted.

The crowdedness of park equipment is also of notable importance. Maroko et al. (2009) measured accessibility through both the density of park space and park equipment. The findings suggest that park space and equipment are distributed unevenly across geographic areas rather than influenced by income, race, or ethnicity. Although the authors did not employ the concepts of functional density and carrying capacity, their examination of park equipment crowding remains pertinent, as unequal equipment distribution can limit access to physical activity resources.

While working on Los Angeles parks, Sister et al. (2010) determine that park equipment and features varies between park areas and that disparities are present depending on socio-economic status and race. In particular, Latinos and African Americans live closer to parks, yet these parks have higher potential congestion. Similarly, they find that more children live in areas with higher potential park congestion (Sister, Wolch, and Wilson 2010). Furthermore, neighborhoods with high potential park congestion are most likely in low-income park service areas. The parks investigated by Sister et al. (2010) are more likely to have the full range of facilities are in areas predominately inhabited by white residents. As a result, there are racial inequities in the diversity and amount of equipment in parks, and therefore, Sister et al. (2010) recommend smaller parks instead of expanding and building large parks to tackle this disparity.

There have been some studies focusing on the perception of crowding without mentioning functional density in a number of different public green spaces. For example, in a study on the mental health benefits of nature in general, Peschardt and Stigsdotter (2012) evaluate park users' perceived levels of crowding as indicators of the social and serene aspects in nine cases of green spaces in Copenhagen, Denmark. Two different studies on parks in Edinburgh, Scotland, and Ljubljana, Slovenia, (Goličnik and Ward Thompson 2010; Marušić 2011) focus on the patterns and behaviors of park users. This is the closest studies have gotten to observing functional density as an aspect of park crowding, despite never mentioning functional density. More specifically, they look at "buffer zones" between users, user groups, and activities (Goličnik and Ward Thompson 2010). However, as park quality was not introduced into the study, the authors note that results would be different if two parks were poorly maintained, empty, or in suburban areas. Therefore, there is still a need to compare different levels and perceptions of crowding as part of park quality and evaluate these dynamics at various parks within a city.

1.6.8 Dissertation conceptualization

In my research, environmental justice helps me theorize and analyze the distribution and accessibility of parks. Guided by this theory, I also draw on other concepts to refine distributional justice. More particularly, I build on the literature on park quality and use, using three indicators to conceptualize park quality: carrying capacity, functional density, and the park context. The depiction of relationships between these concepts is schematized below (Figure 2).

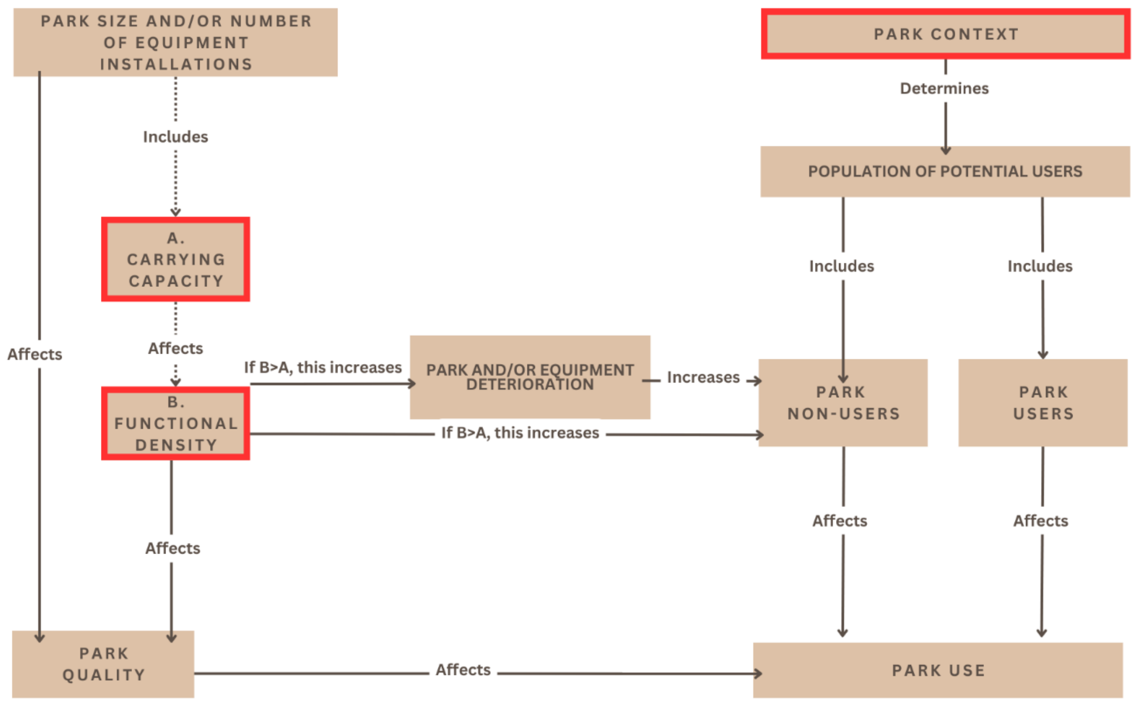

Figure 2. Conceptualization of park quality.

Note: The main quality indicators proposed in this research are outlined in red. Source: Author's illustration synthesized from Bedimo-Rung et al., 2005; Cohen et al., 2010; Lee, 2019; and Pham et al., 2019.

The size of the park determines its carrying capacity, which is the maximum number of visitors it can accommodate. This affects the potential crowding of the park based on the population density it serves (e.g., Sister, Wolch, and Wilson 2010). This terminology derives from gauging the number of people a national park can hold before deterioration (Whyte 1980) and has since been adapted to urban features, such as parks. In addition, the number of different equipment installations in a park also has a carrying capacity that determines the potential crowding of the equipment. There is a certain number of users that the installation can support before deteriorating, and the number of equipment installations in a park impacts park quality.

In other words, there should be enough park space and park equipment to service the residents around the park.

In this dissertation, we draw inspiration from the concept of carrying capacity and use park size as a proxy to measure potential crowding. We characterize park crowding by measuring park visitors' presence and their activities, both temporally and spatially, within the park perimeters. To put it differently, we looked at the number of visitors throughout time and the park space. Although we did not set a threshold to evaluate crowdedness, we consider the spatial patterns of users represented by crowding. Hence, our definition of park quality encompasses both spatial and personal dimensions as recommended by Chen et al. (2020).

Second, to uncover the visitors' perception of park crowding, we draw on carrying capacity is transformed into the park's functional density (the number of people that make a park visit enjoyable). Whyte (1980) discusses functional density using the terminology of "effective capacity" (as a complement to "physical capacity"). The author defines "effective capacity" as "the number of people who by free choice will sit at a place during normal peak use periods" (Whyte 1980, 68). In other words, while carrying capacity is an objective measure of potential crowding, functional density is an experience of crowding by park users. As a result, each place will be different due to how comfortable a person is in the setting. Therefore, functional density cannot result from static numbers and can only be observed through qualitative methods (Whyte 1980). For example, Whyte's research on New York City plazas (1980) highlights that the perception of space discourages use. Low et al. (2005) also address how park accommodation, design, and management can make potential users feel excluded. Consequently, park or equipment deterioration occurs if a park or equipment installation's functional density exceeds its carrying capacity, thus decreasing quality and potentially reducing park users. Similarly, we draw inspiration from the concept of functional density and use park perception as a proxy to understanding the experience of crowding.

Third, the park context is primarily explained by the characteristics of the area around the park and its surrounding population density (e.g., S. Lee 2019). This park context includes both park users and nonusers that influence park use. For example, putting park context above other conceptual terms, if a park's surrounding area has many more children than another park, its playground will experience more use than the other. Depending on the different parks and equipment installations, this can also be the case for other age groups, such as adolescents or seniors. These could look different considering urban core and suburban parks. Therefore, there is a need to look at the park's carrying capacity and functional density in terms of its socio-demographic context. Usually, studying a park's context would include the neighborhood's socio-demographic profile, economic status, and urban form. At first, when answering the first research question, the socio-demographic profile and economic status are examined while assessing environmental inequities. Afterward, this dissertation focuses on the density of the surrounding neighborhoods to compare the crowding and perception of crowding once inside the park. The socio-demographic and economic profiles of the surrounding neighborhoods are then not utilized to conceptualize park quality.

Finally, park use is characterized by the number of visits or visitors and the length of visits. Several factors, including park quality, maintenance, and accessibility, impact park use (Bedimo-Rung, Mowen, and Cohen 2005; Rung et al. 2011). Regarding park quality and maintenance, overcrowded parks (either in terms of size or equipment) tend to discourage users because of park deterioration and competition for space and equipment which will then discourage park users. If the functional density is higher than the carrying capacity, there are more chances of park deterioration, which can most likely increase the number of park nonusers. This is because the park has more visitors than it can support (overcrowded). Second, people can be discouraged from visiting a park due to bad quality or long travel times from home (underused parks). Lastly, users' perception of park maintenance can discourage usage or call attention to highly used parks (Rung et al. 2011). Moreover, park use is influenced by users' perceptions of accessibility, either in terms of distance, safety, or inclusiveness (Byrne and Wolch 2009). In this regard, studies have included indicators that measure perceived or realized accessibility outside of park proximity (e.g., Maroko et al. 2009). Together, these concepts will allow me to shed light and expand on access to quality parks in Greater Montreal.

CHAPTER 2: METHODOLOGY

This chapter presents the detailed methodology developed to answer the research questions. Given the conceptual and theoretical framework, a subsequential multi-methods approach is adopted to address this project's different scope variances and respond to each specific research question. The following chapter focuses on 1) the study area, 2) the selection of multi-methods and their utility for this project, and 3) the methodology for each of the three research questions.

2.1 Study area

This study focuses on the 82 municipalities of Greater Montreal governed by the Montreal Metropolitan Community (also known as: MMC or Communauté métropolitaine de Montréal in French) and inhabited by 3.8 million people over 4374 km2 in 2016 (Figure 3). As shown in Figure 3, the MMC comprises five zones: Montreal, Laval, Longueuil, the North Shore, and the South Shore, as well as 3,915 parks. Greater Montreal's diversity in urban form, residential neighborhoods, and diverse population groups make it an ideal case to examine park quality, park crowding, usage, and perception. Furthermore, the MMC has committed to increase the provision of parks and has continued to advocate for protection of green space within the area (CMA 2019).

Montreal park research has mainly focused on neighborhood parks in the inner city of Montreal or Montreal Island (S. Moore et al. 2010; Apparicio et al. 2010; Coen and Ross 2006; Reyes, Páez, and Morency 2014). One exception is a study on the MMC, focusing solely on playgrounds and not parks (De Alvarenga, Apparicio, and Séguin 2018). They found no systematic environmental inequity for children, single-parent families, low-income families, and visible minorities. However, children in central areas lived closer to potentially congested playgrounds than their suburban counterparts (2018).

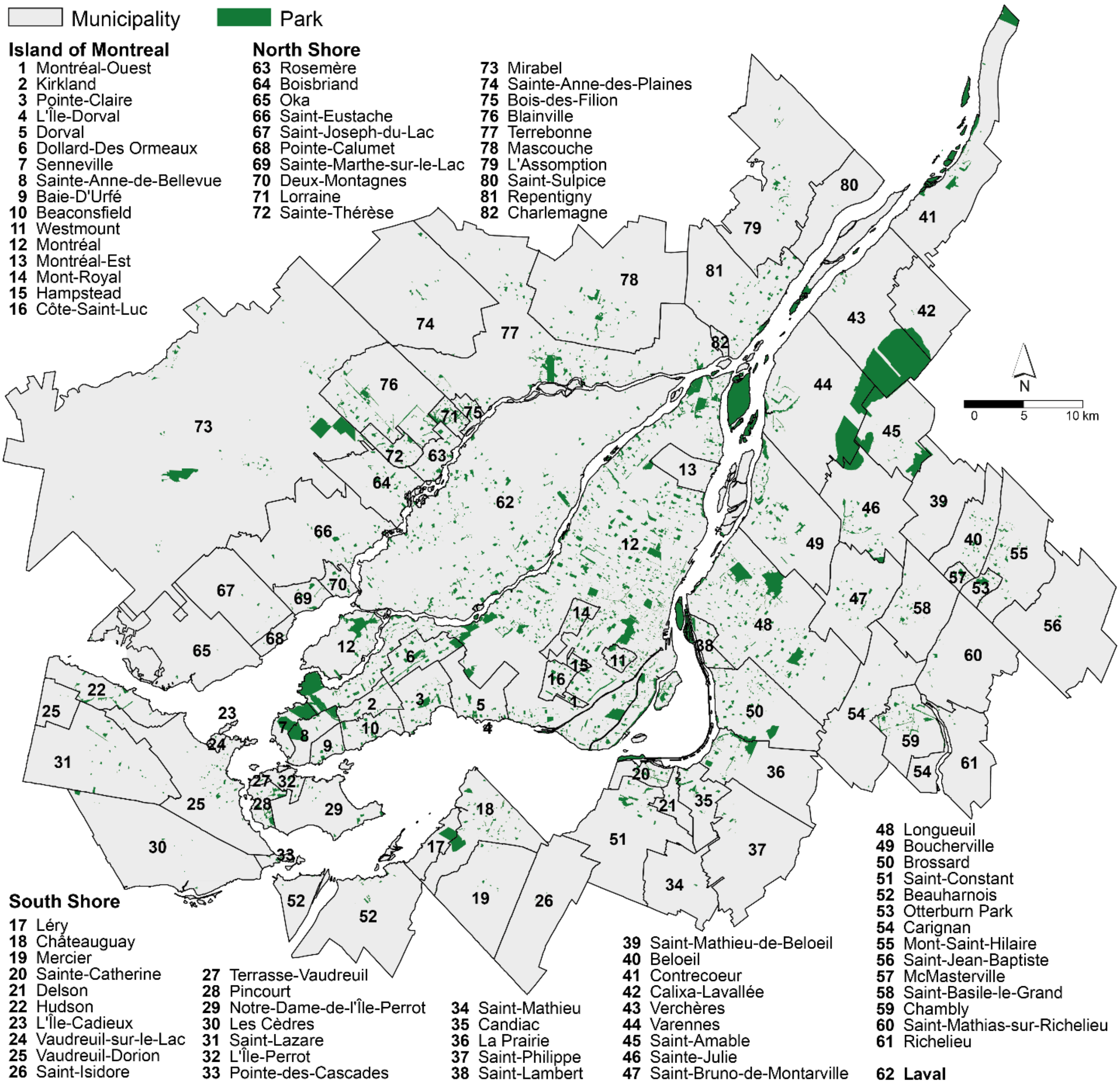

Figure 3. Park locations and municipalities of Greater Montreal.

Source: Communauté métropolitaine de Montréal, 2016.

Within this study area, subsequent neighborhood parks are selected to answer sub-questions 2 and 3. These parks are selected from the spatial analysis conducted in question 1 (detailed below in Section 2.4). The parks chosen are Parc Bourbonnière, Parc de Bucarest, Parc Bariteau, Parc Chamberland, Parc Wilson, and Parc Hochelaga (Figure 4).

Figure 4. Parks selected for analysis in questions 2 and 3.

A) Parc Bourbonnière, B) Parc de Bucarest, C) Parc Bariteau, D) Parc Chamberland, E) Parc Wilson, and F) Parc Hochelaga. Source : Jepson, June 2022.

2.2 Multi-method approach

This project is conducted with a sequential explanatory strategy using multi-methods research and considering the research problem's background. Based on Small's (2011) three axes of reflection in choosing and elaborating a mixed-design method, the following project is complementary and sequential. This means that every sub-question builds upon itself and complements each other in view of the larger research question.

Compared to mixed methods studies that integrate different methods throughout the process (Creswell 2009), a multi-methods study uses different methods at different phases and are then integrated during the analysis (Anguera et al. 2018). The use of separate data collections in multi-methods research is sometimes criticized for being time-consuming (Hunter and Brewer 2015). Despite its limitations, this approach is relatively easy to implement, explain, and present, given that each stage builds upon the previous one. This allows for analyzing each step and the project's bigger picture.

In line with the multi-method approach, this project first uses geographical information systems (GIS) operations and spatial analyses, followed by observations and surveys for the second and third questions (Figure 5). The results of the first quantitative analysis in the first question allows us to select park for the subsequent questions. This multi-methods approach identifies broad tendencies concerning park access and adds depth to park usage and perception concepts.

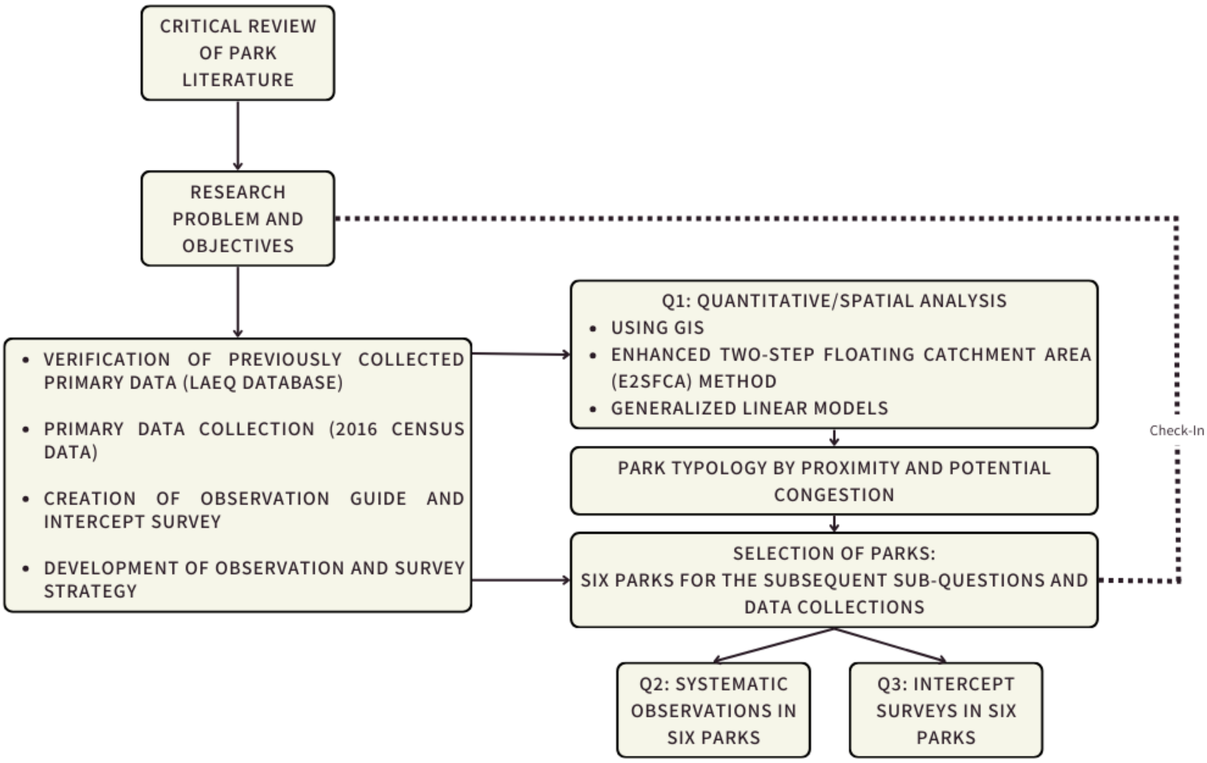

Figure 5. Research strategy.

Source: Author’s Illustration.

Weight is given to the first quantitative phase to inform the data collection in the second and third questions. The limitations of a one-method approach, on its own, provides the research only with a more positivist analysis of park accessibility, meaning using empirical data to understand park accessibility. As such, it only provides a snapshot of normative park quality and may overlook indicators affecting park use. Without the complementary methods detailed below, this research would miss the experience of park users and the lived realities of park quality underlined by previous studies (Mannik and McGarry 2017; van de Sande and Schwartz 2017). As part of a larger research project, the strategy’s strengths in determining park carrying capacity and accessibility outweigh these limitations.

2.3 Methodology for the first research question

As a reminder, the first research question is *“How does the accessibility to parks vary across different population groups (e.g., low-income, visible minorities, children, seniors) in Greater Montreal according to a park’s proximity and carrying capacity of park size/equipment?”* [1].

The concept of carrying capacity and use park size in this section are used as a proxy to measure potential crowding. This section refers to potential congestion as a result of the E2SFCA method further elaborated below.

2.3.1 Primary and secondary data collection

First, primary GIS data on Greater Montreal municipal parks was collected in 2016 and finalized in 2017 by the LAEQ (Laboratoire d’équité environnementale, INRS). The data includes details on park location, surface area, and the location of different park facilities collected first by reviewing satellite images and further confirming on field visits if there were discrepancies (Table 1).

Table 1. Database levels.

Geographic Layers	Information
Dissemination Area (DA)	2016 Census Data (DA): percentages of children and seniors, low-income households, and visible minorities
Regional County Municipality (MRC) Municipalities	
Sector	2016 Données Québec
Land Use	2016 Données Québec
Residential Land Use	2016 Données Québec
Parks (polygons)	Park attributes: Location (X, Y), municipality, area, short name, long name, presence of equipment (yes/no) (see table 2)
Equipment installations within parks (point)	

[1] This section includes in part the methodology from the following article: Victoria Jepson, Philippe Apparicio & Thi-Thanh-Hien Pham (2022) Environmental equity and access to parks in Greater Montreal: an analysis of spatial proximity and potential congestion issues, Journal of Urbanism: International Research on Placemaking and Urban Sustainability, DOI: 10.1080/17549175.2022.2150271.

This section, however, is further developed to include details of the methodology.

The facilities recorded by the LAEQ in 2016 for each park are in Table 2. It is, therefore, possible to see, for example, the number of baseball fields and the presence of different types of equipment within the park. I updated and verified the 2016 park database before the first analysis in 2021 with satellite images to include new equipment installations that may have been built since the data collection. No new parks were added and the 2021 satellite images were also used to verify park layout if mapping issues occurred in QGIS.

Table 2. List of facilities in all Greater Montreal parks.

Children's facilities	**N**	**Indoor facilities**	**N**
Playground	2169	Arena	42
Water play area	286	Park building or shelter	626
Wading pool	234	Restrooms	175
Sports areas		Swimming pool	20
Badminton	2	**Recreational facilities**	
Baseball	401	Archery	8
Basketball	530	Barbecue	3
Basketball (half court)	218	Croquet / bocce	104
Cricket field	3	Horseshoes	36
Football	95	Outdoor dancefloor	7
Hockey rink (summer)	128	Pétanque	234
Outdoor exercise equipment	56	Picnic area	351
Rugby	7	Ping-pong tables	13
Soccer field	691	Rest area	144
Soccer (synthetic field)	101	Shuffleboard	28
Track and field	78	**Outdoor winter facilities**	**N**
Tennis	317	Cross-country skiing trails	34
Volleyball	12	Hockey rink	399
Beach volleyball	124	Skating rink	368
Other sport facilities		Toboggan slides	114
BMX track	13	Snowshoeing trails	25
Inline skating rink	4	Skateway	76
Outdoor swimming pools	195	**Scenic activities**	
Rock climbing wall	14	Pond	68
Wall ball court	10	Bird watching / sanctuary	25
Skatepark	104	**Nautical activities**	
Other facilities		Beach	22
Bicycle path	201	Boat ramp	79
Dog park	91	Kayak and canoe	12
Hiking trails	260		

Second, sociodemographic data were extracted from the 2016 Census of Statistics Canada at the dissemination area (DA) level for four population groups: children, seniors, low-income individuals, and visible minorities (chosen according to the literature shown in Chapter 1). The DA unit is the smallest scale (usually 400 to 700 persons) on which sociodemographic data are disseminated by Statistics Canada (2017). Percentages, as opposed to total number of people, are used in this research question as a way to demonstrate proportional inequities and helps compare regardless of population size. This further helps with the analysis of environmental inequities in terms of spatial accessibility and potential crowding.

The spatial distribution of the four population groups is shown in Figure 6. There is a larger percentage of the low-income and the visible minority population living in the urban core of Greater Montreal. Children tend to live in the outer suburban areas and seniors 65 years and older are more spread throughout the study area.

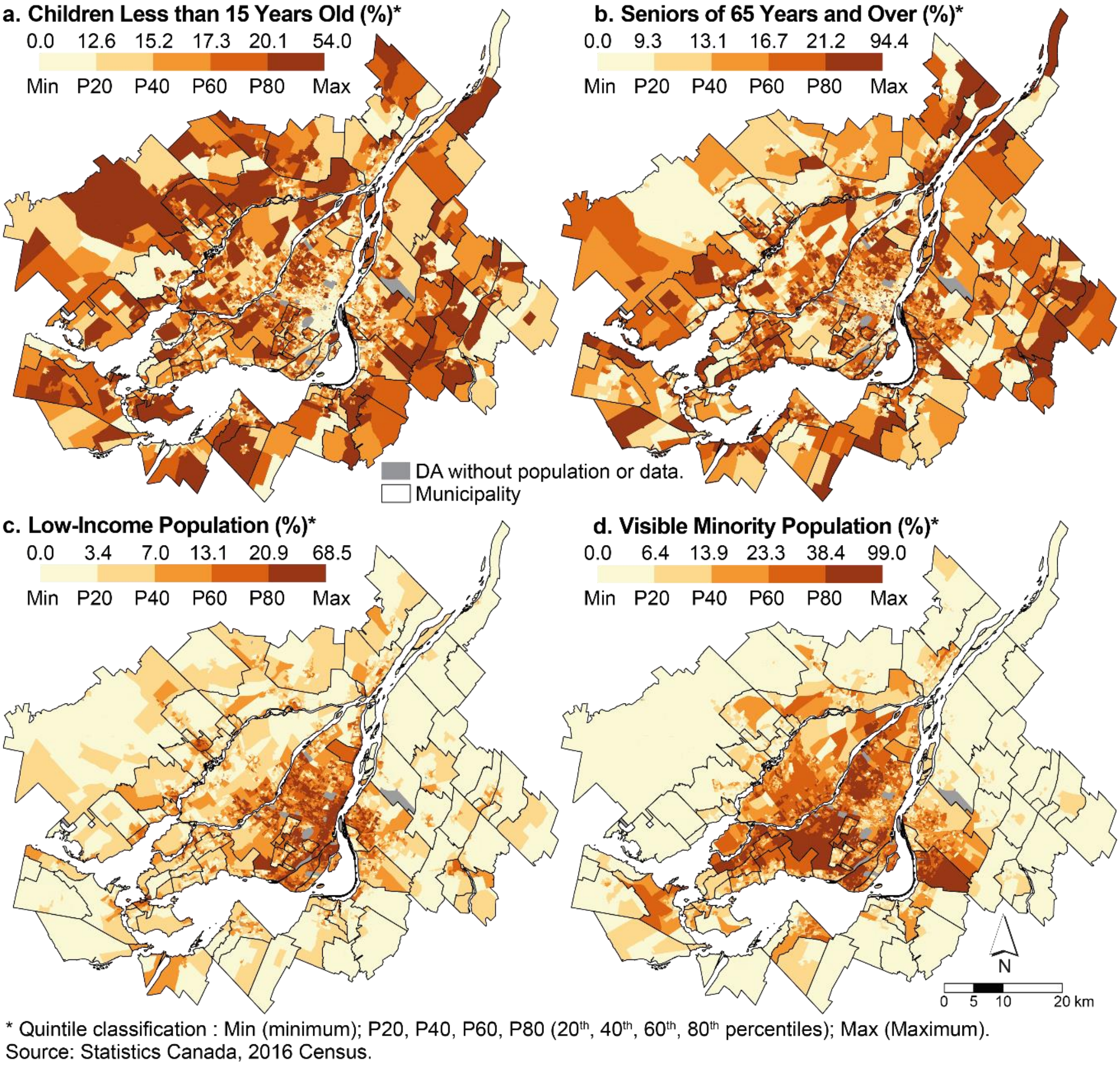

Figure 6. Distribution of the four selected population groups at the dissemination area level in Greater Montreal.

Source: Statistics Canada, 2016.

2.3.2 Evaluating spatial accessibility and potential park congestion

Two adjustments are performed before computing the spatial access measures. First, it should be noted that the network distances are computed using two points, not polygons, snapped along the road network. In order to compute distances from census blocks to parks, points were added along each park perimeter with an equidistance of 20 meters as Apparicio and Séguin (2006). This approach is more accurate than using the park centroid, as with a distance of 20 meters, the maximum potential error is 10 meters (Apparicio and Séguin 2006). Second, to minimize aggregation errors (Apparicio et al. 2017; Hewko, Smoyer-Tomic, and Hodgson 2002), the accessibility measures were initially computed with the street block centroids. As such, we calculated the population-weighted mean of each accessibility measure for these blocks (n=26,486) within the dissemination areas (n=6,031). The network distances are computed by using the ArcGIS Network analysis extension (version 10.5) and the street network of the City of Montreal (GéoBase).

Two spatial measures of accessibility are computed. First, to evaluate the immediate proximity, we calculate the shortest walking distance between DAs and parks (we named this measure “the closest park”) by using the street network and excluding highways (Equation 1). Second, to evaluate the potential park congestion based on supply (either park area or park facilities) and demand (population), we use the enhanced two-step floating catchment area (E2SFCA) method with a continuous gradient function (Apparicio et al. 2017; McGrail 2012) (Equations 2, 3, and 4). Initially, several versions of the E2SFCA method were used to assess accessibility to healthcare services (Luo and Qi 2009; Luo and Wang 2003; Luo and Whippo 2012; Wan, Zou, and Sternberg 2012). Recently, a number of authors have used E2SFCA to assess park congestion in different urban contexts (Dai 2011; Hoang, Apparicio, and Pham 2019; Martori, Apparicio, and Séguin 2019; Wei 2017; L. Xing, Liu, and Liu 2018).

The population-weighted mean minimum distance to any park for a given DA *i* can be written as:

$$A_i = \frac{\sum_{b \in i} w_b (min[d_{bj}])}{\sum_{b \in i} w_b} \quad \textbf{(1)}$$

where w_b is the total population of the census block *b* completely within DA *i* and d_{bj} is the walking network distance between census block *b* and park *j*.

Concerning the E2SFCA with a continuous gradient function, the first step assigns an initial ratio for each park R*j* which represents the number of hectares or facilities for 1000 inhabitants within one kilometer:

$$R_j = \frac{S_j}{\sum_{b\in\{d_{bj}\leq d_0\}}(P_{k/1000})W_{bj}} \quad \textbf{(2)}$$

where d_{bj} is previously defined, S_j is the supply capacity of park *j* (hectares or number of facilities), P_k is the number of inhabitants that live within the catchment area, and W_{bj} is the weight for block *b* with a continuous weighting function. For this study, the threshold distance (to determine the catchment area) d_0 is fixed at 1000 meters, and the W_{bj} is calculated as follows:

if $d_{bj} < 250$ then $W_{bj} = 1$;

if $d_{bj} > 250$ and $d_{bj} \leq 1000$ then $W_{bj} = \left(\left(1000 - d_{bj}\right)/(1000 - 250)\right)^{1.5}$

if $d_{bj} > 1000$ then $W_{bj} = 0$ **(3)**

In the second step, for each block *b*, we search all parks within 1000 meters (d_0), sum up the initial ratios R_j (numerator of the following equation), and then divide this sum by the number of blocks within the dissemination area (n_i) to obtain the mean for the DA *i.*

$$A_i = \frac{\sum_{b\in i}\sum_{j\in\{d_{bj}\leq d_0\}} R_j}{n_i} \quad \textbf{(4)}$$

For each DA, the E2SFCA equals the number of park hectares or facilities for 1000 inhabitants within a threshold distance of 1000 meters. This value allows us to evaluate the potential park congestion for the nearby residents: the larger the E2SFCA is, the lower the park congestion in terms of park area or park facilities.

In summary, three accessibility measures are obtained: 1) closest park (shortest walking distance) (eq. 1), 2) potential park area congestion (gradient E2SFCA, hectares per 1000 inhabitants) (eq 3 S_j as park area in hectares in eq. 2), and 3) potential park facility congestion (gradient E2SFCA, facilities per 1000 inhabitants) (eq 3 with S_j as number of park facilities in eq. 2). Following Martori et al.'s study of playground accessibility in Barcelona (2019), we create typologies of park access by cross-tabulating the closest park measure with each E2SFCA measure (by quintiles). These cross tabulations illustrate the complexity of the potential spatial accessibility to parks, reflecting immediate proximity and potential park congestion.

2.3.3 Evaluating environmental inequities

To verify the existence of environmental inequities for the four selected population groups (children, seniors, low-income individuals, and visible minorities), three types of statistical analyses are conducted in the R software (R Core Team 2021).

First, weighted t-tests, computed with the *sjstats* package (Lüdecke 2021), are used to compare the means of three accessibility measures between each population group and the rest of the population (e.g., 0–14 years old *versus* 15 years old and over). If, for example, the 0-14 years old population has, on average, a lower proximity to parks compared to the rest of the population, we can say there is an inequity for the 0-14 years old population. Second, three generalized linear models (GLM) are built: one for each accessibility measure introduced as a dependent variable and the four population groups in percentages as independent variables. Due to non-normal distributions, the three GLM models are performed with a log normal distribution. These models allow us to estimate the variation of the park measures in function of the percentage of the population group (while the t-tests only provide mean values of the park measures). Third, two multinomial logistic models are conducted, with the two typologies—obtained with the cross tabulation of E2SFCA and closest park measures quintiles—as dependent variables and the four population groups as the independent variables. These models allow the identification of population groups that significantly predict the likelihood of a DA belonging to a specific accessibility category. At this stage, there is no control variable for the differences between urban core and suburban park access as the typologies derived from these models capture the different urban characteristics. All regression models are performed using the *VGAM* package (Yee 2015). Note there is no excessive multicollinearity among the four population groups (the maximum value of the variance inflation factor is 1.62).

2.4 Methodology for the second research question

As a reminder, the second research question is, *"How does park crowding differ in the function of park profiles and usage patterns?"*[2].

2.4.1 Park selection

Six parks were selected based on a spatial analysis of dissemination areas (DAs) in Greater Montreal using two accessibility measures: closest park (shortest walking distance) representing proximity to residential areas and facilities per inhabitants (gradient enhanced two-step floating catchment area) that represent park potential congestion. The selection of these parks was based on four criteria:

1) Three suburban parks and three urban core parks in the City of Montreal.

2) Park size falling under neighborhood park classification (between 0.7 and 3.0 hectares).

3) Park facilities (minimum of two different facilities, including a playground).

4) Varying levels of park proximity and potential congestion (low level of proximity and low level of park congestion, low proximity and high congestion, high proximity and low congestion, high proximity and high congestion as computed in the previous chapter).

The exclusion criteria included all parks with natural water features, bordering water or other parks, or containing large, forested areas. This was done to respect the park size and provide a park selection with similar perimeters.

The six parks selected for questions 2 and 3 and the subsequent data collection are Parc Bourbonnière, Parc de Bucarest, Parc Bariteau, Parc Chamberland, Parc Wilson, and Parc Hochelaga (Figure 7). Table 3 presents the neighborhood context of each park, including park size, levels of proximity, and potential congestion, as well as percentages of different age groups within a 400m walking distance around the park. The location and configuration of

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[2]This section includes in part the methodology from the following article: Victoria Jepson, Thi-Thanh-Hien Pham & Philippe Apparicio (2024) How do parks and park use differ across a metropolitan region? Six parks in Greater Montreal, Canadian Journal of Urban Research.

This section, however, is further developed to include details of the methodology.

these six selected parks are presented in Figure 7. The colors in the figure separate the parks' different accessibility combinations found in Table 3.

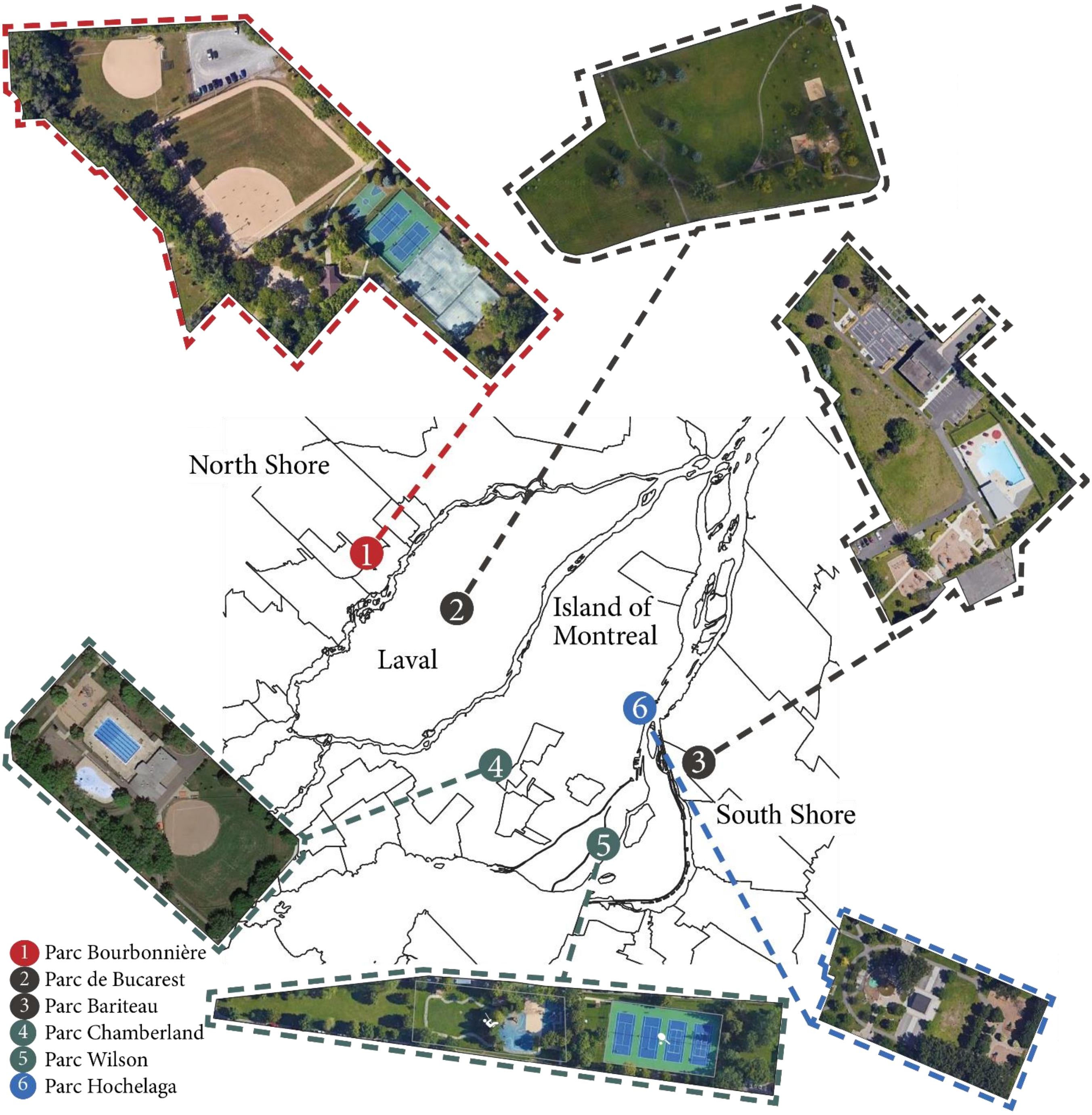


Figure 7. Location, configuration, and classification of the six selected parks in Greater Montreal.

Source: Author's Illustration.

Table 3. Neighborhood context and park details.

	Location	Park Size	Accessibility[a]		Neighborhood context within a walking of 400 meters[b]					
Park		Hectare	Prox.	Cong.	Pop.	Inha/km^2[b]	% 0-14[c]	% 15-24[c]	% 25-64[c]	% 65+[c]
Parc Bourbonnière	Suburb	3.0	Low	Low	432	430	17.4	11.1	53.5	18.1
Parc de Bucarest	Suburb	1.7	Low	High	1776	4230	15.4	12.7	56.9	14.9
Parc Bariteau	Suburb	1.7	Low	High	2445	3634	9.5	9.0	53.2	28.3
Parc Chamberland	Urb.Core	1.3	High	Low	1083	4533	18.8	14.4	48.1	18.7
Parc Wilson	Urb.Core	1.7	High	Low	3779	10248	16.1	8.8	59.0	16.2
Parc Hochelaga	Urb.Core	0.8	High	High	7893	14682	10.7	12.6	68.1	8.6

[a] Proximity and potential congestion based on the typology proposed by Jepson, Apparicio, and Pham 2022. [b.] Census 2016 (Statistics Canada 2017). [c.] Age classifications based on Statistics Canada (2017): Children, Teens and young adults, Adults, and Seniors.

The first selected park, Parc Bourbonnière, is located within a DA categorized by low park proximity levels and potential park congestion. This situation is often found in low-density urban areas like suburban neighborhoods. The following two parks, Parc de Bucarest and Parc Bariteau, are in DAs with low proximity and high potential congestion, and both are located in the suburbs. This suggests fewer users and low crowding in the parks. Two other parks, Parc Chamberland and Parc Wilson, are in DAs categorized by high proximity and low potential congestion. They are located in the urban core which is categorized by a higher number of users and crowding; however, these parks are both found in DAs with the most favorable situation. The last park, Parc Hochelaga, is selected from a DA categorized by high levels of park proximity and potential park congestion. This is a typical situation in old urban core neighborhoods, suggesting a very high level of crowding.

Finally, the different parks' facilities are mapped in Figure 8. Regarding sports facilities, there are baseball fields, basketball courts, a swimming pool, and tennis/pickleball courts. Beyond sports, facilities include playgrounds, pétanque, and water play areas. Picnic tables and benches count as facilities though they are not pictured in Figure 8. Occasionally, the picnic areas are found near the playgrounds or sports facilities. Among the three parks in the urban core, Parc Chamberland's last major renovation was in 2010, when a new pool building was constructed, in addition to modern playground equipment. Parc Wilson, first inaugurated in 1951, recently reopened in 2017 after major renovations to the playground and tennis/pickleball courts. Parc Hochelaga, officially inaugurated as a park in 1930, had its last renovation in 2009. The three parks in the suburbs are newer. Parc Bourbonnière, one of Rosemère's three large parks inaugurated in 1974, had its first significant renovation in 1992 and provided sports field maintenance. Parc Bariteau, in 2015, inaugurated renovations, including a new pool and modern playground equipment. No creation date has been found for Parc de Bucarest; however, its playground equipment is the most outdated.

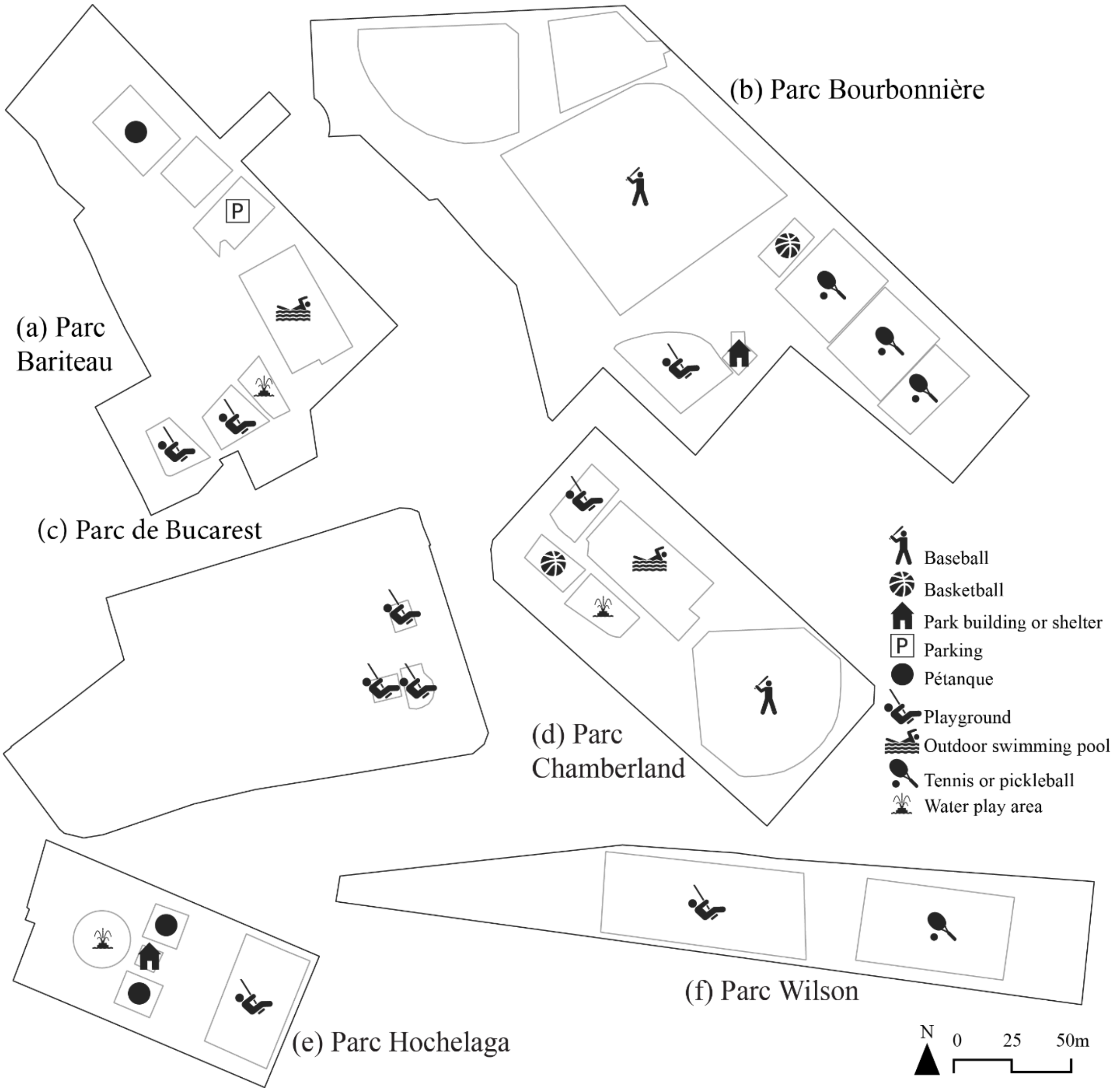


Figure 8. Facilities in the six parks.

Source: Author's Illustration.

2.4.2 Observation data collection

Each park was first visited to ensure that it was an appropriate study site, and a first evaluation of the park site was made with the checklist (Table 4). The checklist helped easily record observations on equipment, movement, and crowdedness. The park's amenities, overall maintenance (lawn, litter, etc.), and park events were noted. For equipment, a score ranking was given on a scale of one (very good) to three (poor) based on criteria such as functionality, degradation, and material. For example, a rating could be made if an equipment site like a soccer field is on gravel, grass, or cement. For observing crowdedness, things like the presence of lines at the playground or overflowing trash cans can be indicators of frequentation.

Table 4. Pre-data collection park evaluation.

Name of park : ____________________ **Date :** ________ **Hour :** ____________

Verification and evaluation of each park facility and its condition

Title	Options	Response
Equipment	Equipment type: drop-down menu for equipment list	**Geographical coordinates (x,y)**
	Classification of equipment condition	**Only one answer in a drop-down menu:** 1. Good condition 2. Average condition 3. Poor condition
	Justification for classification	**Open answer :** • Signs of deterioration? • Works well?

General information on the park

Title	Options	Response
Signs of crowding	Are there queues?	**Only one answer in a drop-down menu:** 1. Yes 2. No
	Are garbage cans usually full or overflowing?	**Only one answer in a drop-down menu:** 1. Yes 2. No
	Other signs of crowding	**Open answer:** additional notes
Infrastructure conditions	Notes on vegetation	**Open answer:** tree density, floral design, etc.
	Notes on grass or open spaces	**Open answer:** open spaces, quality of grassed areas
	Notes on the presence of garbage	**Open answer**
	Notes on the presence of events (recreational and cultural activities, etc.)	**Open answer**
Around the park What is around the perimeter of the park?	Notes on roads within the park perimeter	**To be described:** street types, parking, bus stops, metro stations, etc.
	Notes on buildings	**To be described:** residential housing, shops, etc.
	Notes on the presence of obstacles limiting access to the park	**To be described:** fences, stairs, road dividing the park in two, etc.

Then, non-participative observations in the six parks were conducted over two weeks in June 2022. There was a morning observation period from 9h to 12h, an afternoon period from 12h to 15h, and an evening period from 15h to 18h. These periods of observations were three hours long, and time slots differed during the week to capture a representative sampling of the whole week as follows: Monday (15h-18h), Tuesday (12h-15h), Wednesday (9h-12h), Friday

(15h-18h), Saturday (9h-12h), and Sunday (12h-15h) (Figure 9). We initially planned to accomplish 288 observation blocks (each observation block lasting 30 minutes) which would have resulted in 144 hours of observations. The observations were conducted during sunny days to represent optimal park usage. Three observation periods were postponed because of rain and were rescheduled for the same time slot the following week. However, consecutive Thursdays and Saturday afternoons of rain eliminated these time slots from the data collection, resulting in a total of 216 observation periods and 108 hours of observations.

At every hour, two blocks of observations were conducted (for example, at 10h and 10h30). In one observation period of three hours, there would be a total of six observation blocks where each user was counted. As a result, if a person was on a bench for hours their geolocation was recorded 4 times (once every 30 minutes). This accounted for different park uses overtime, however, it did not account for individual movements throughout the park. The swimming pool in Parc Chamberland opened during the week of observation and the only other pool, located in Parc Bariteau, did not open until after the data collection. No special events took place.

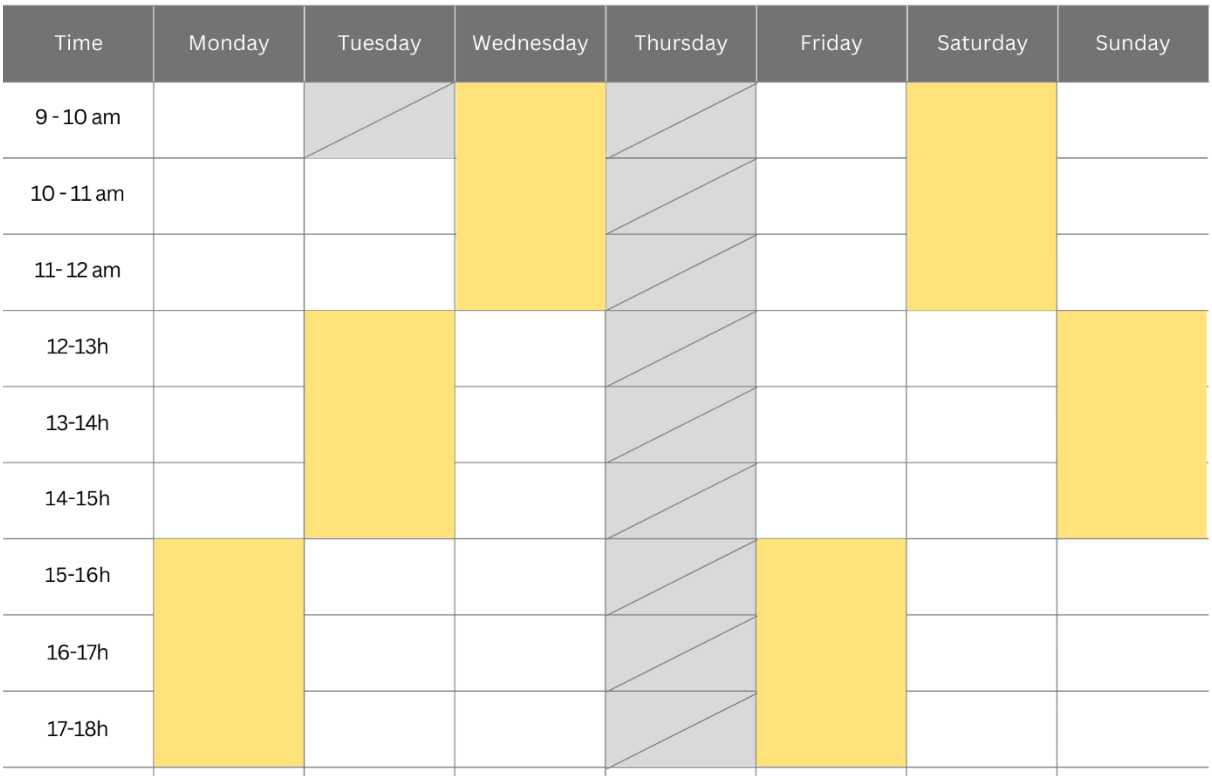


Figure 9. Data collection time periods.

Source: Author’s Illustration.

Observations were recorded using the ArcGIS Survey123 on cell phones. The survey for the observations was developed before the data collection, and five student research assistants (graduate students in Urban Studies) attended training beforehand to ensure concurrency. For each observation, we noted the geolocation (by positioning a point in ArcGIS Survey123) of users staying in the park for more than five minutes (Table 5). The parks were small enough in size that a single research assistant survey the whole park and would note the geolocation from a distance. The ArcGIS Survey123 application allowed for the geolocation to be pretty precise.

The research team members were encouraged to keep a fieldwork journal noting information related to the weather conditions, special events occurring in the park during the observations, such as a sports tournament or cultural activity, as well as the general appreciation of park crowding or park usage. The data was downloaded, cleaned, and organized on QGIS. The observation points were organized by park, time, and activity. At this point, the journals were also used to confirm unclear observations from the survey. The Research Ethics Board of INRS approved the study protocol (project No. CER-22-656).

Table 5. Observer questionnaire.

Title	Options to choose or fill in	Response
Observer	To be completed in a drop-down menu	
Date, time	Date and time	
Park	Drop-down menu with the six parks	
Period of observation	☐ Morning	**Only one answer in a drop-down menu:** • 9 h 00 to 9 h 30 • 9 h 30 to 10 h 00 • 10 h 00 to 10 h 30 • 10 h 30 to 11 h 00 • 11 h 00 to 11 h 30 • 11 h 30 to 12 h 00
	☐ Afternoon	**Only one answer in a drop-down menu:** • 12 h 00 to 12 h 30 • 12 h 30 to 13 h 00 • 13 h 00 to 13 h 30 • 13 h 30 to 14 h 00 • 14 h 00 to 14 h 30 • 14 h 30 to 15 h 00 • 15 h 00 to 15 h 30 • 15 h 30 to 16 h 00
	☐ Evening	**Only one answer in a drop-down menu:** • 16 h 00 to 16 h 30 • 16 h 30 to 17 h 00 • 17 h 00 to 17 h 30 • 17 h 30 to 18 h 00

		• 18 h 00 to 18 h 30 • 18 h 30 to 19 h 00 • 19 h 00 to 19 h 30 • 19 h 30 to 20 h 00
User group size	☐ One person	**To be described:** • Gender • Age: Under 14, 15-24, 25-65, 65 and over • Visible minority: Yes, No
	☐ Pair (group of 2-3)	**Describe:** • Person 1: Gender, age, visible minority • Person 2: Gender, age, visible minority • Person 3: Gender, age, visible minority
	☐ Group 1 : 4-5 people	**Description:** age and gender and visible minorities
	☐ Group 2 : 6-10 people	**Description:** age and gender and visible minorities
	☐ Group 3 : 11-20 people	**Description:** age and gender and visible minorities
	☐ Group 4 : >20 people	**Description:** age, number of people, gender, and visible minorities
Describe the observation *Activity checklist (can select more than one)* (Temporary: depending on the park, infrastructure can be added)	**Tick one of the following boxes:** ☐ Passive activity (reading, writing, watching, talking, eating, using telephone, etc.) ☐ Exercise (i.e., individual, class, group, uses equipment) ☐ Playground ☐ Free play ☐ Organized play ☐ Police or security ☐ Unhoused ☐ Playing music ☐ Listen to music ☐ Drinking alcohol ☐ Smoking (cigarettes, electronic cigarettes, cannabis, etc.) Other: _________	
Geographical location	x,y	
Additional information	Open answer:	

2.4.3 Statistical and visual analyses

Two types of analyses were conducted. First, bivariate analyses (contingency table and chi-square test of independence) were conducted to examine associations between the six parks and five variables representing park crowding: the number of people according to activity type, days of the week, time period, age group, and group size. These were calculated using R software (R Core Team 2021).

Second, we used point maps, proportional circles, and kernel densities to explore how the five variables of park crowding changed within each park, inspired by the work of Ostermann (2010), Mehta and Mahato (2020), Marušić (2011), and Goličnik and Ward Thompson (2010). For the point maps and proportional circles, it is important to keep in mind that one point represents an observation, whether an individual or groups of people visiting together. To calculate the kernel density estimations, we used a radius of 10 meters, a pixel size of 50 centimeters, a quadric kernel function, and a weighting for each observation. The weightings were based on the group size category as follows: 1 (single visitor), 2.5 (2 or 3 people), 4.5 (4 or 5 people), 8 (6 to 10 people), 15 (11 to 20 people), 25 (more than 20). This allows a more accurate visual of park crowding.

We also conducted correlation analyses between the five variables of crowding –activity type, days of the week, time period, and age group–to verify if their spatial patterns are similar or not. For example, a correlation between two kernel density maps of the weekday and the weekend can tell us if users occupied the same park space during the week and the weekend. We could not calculate kernel density estimations for group sizes as it is the weighing for each variable; therefore, proportional circles are used to portray park use.

2.5 Methodology for the third research question

As a reminder, the third research question is, *"How do visitors' behavior influence the frequency of visits, duration, and perception of crowding in Greater Montreal parks?"*

2.5.1 Survey data collection

Surveys were conducted on the same collection days as observations: before or after the three- or four-hour block (e.g., Monday from 15h to 16h) on ArcGIS Survey123. In other words, one to two hours per day were spent conducting the surveys, and we planned to reach 50-70 surveys per park. The survey time was estimated to be 5 to10 minutes and I conducted them with the same team of five research assistants who signed the confidentiality agreement.

Recruitment of participants for the intercept surveys was based on a non-probability quota and convenience sampling method, with three target population groups: parents with children, seniors, and ethnocultural minorities (excluding minors), keeping in mind as much as possible gender parity. Park users were asked to participate in a short 5 to 10-minute survey. Participants were informed of the nature and objectives of the study via the information letter when they were solicited for participation. Participants were required to read the information letter and sign the consent form. They also received a copy of the consent form for review. No financial compensation was offered to survey participants.

The objective was to have about 50 to 70 participants for each of the six parks (about six participants by day); however, due to the variations in park use, research assistants were asked to get the most possible surveys in their capacity, resulting in 150 surveys total. Intercept surveys were conducted in the six parks, either in French or English (Table 6 presents the English version). We read out the responses and selected which one the respondents answered.

Table 6. English version of the intercept survey.

Park name:	**Date:** _________	**Time:** ____________
Theme	**Question**	**Response**
Activities and company	What is the main reason for your visit to the park today?	**Dropdown menu:** 1. To be in nature 2. Meditation/Solitude 3. Picnic or gathering 4. Accompany children to the playground 5. Walking/Jogging 6. Bike 7. Practicing a sport (e.g., soccer, baseball) 8. Outdoor Exercise Equipment
	Did you come to the park alone or accompanied?	**Checkboxes:** ☐ Alone ☐ With kids ☐ With other family members ☐ With friends ☐ With coworkers ☐ In an organized group (e.g., sports team)
Park uses	How long is your visit today?	**Dropdown menu:** 1. Less than 15 minutes 2. 15 to 30 minutes 3. 30 to 60 minutes 4. 1 to 3 hours 5. More than 3 hours
	How often do you come to this park?	**Dropdown menu:** • Daily • A few times a week • Once a week • Once a month • Few times a year • This is the first time
Park Crowding	Do you ever find this park crowded?	**Dropdown menu:** 1. Very often 2. Often 3. Sometimes 4. Rarely 5. Never
	Have you or someone you know decided not to visit the park because it was crowded?	**Dropdown menu:** 1. Very often 2. Often 3. Sometimes 4. Rarely 5. Never
Respondent Characteristics	How did you come to the park today?	**Dropdown menu:** 1. Walking 2. Bike 3. Public transportation 4. Car 5. Other: ---------
	How old are you?	Open answer: _____
	What is your gender identity?	Open answer: _____
	What is your race/ethnicity?	Open answer: ________________
	Any additional comments to share about the park?	Open answer: _____

	What is your total personal income?	**Drop down menu:** 1. Without income 2. Less than $10,000 3. $10,000 to $29,999 4. $30,000 to $49,999 5. $50,000 to $69,999 6. $70,000 to $99,999 7. $100,000 and over 8. Do not wish to answer

These categories were selected to contextualize visitors' behavior going to the park and once in the park. We observed activities, usage patterns, crowding levels, and the characteristics of respondents to determine whether these factors influence the frequency and duration of park visits, as well as perceptions of crowding. The transport mode is recorded to see how park users get to their respective park and to compare between different neighborhood densities. Gender and visible minority member identification are self-reported to address use in each respective park. Income levels can examined to identify potential differences in perceptions of park use, particularly since individuals with higher incomes may be homeowners with access to private green spaces. Finally, park type, the day and time of the visit, and the reasons for visiting are all characteristics that can provide insight into how they influence visit frequency, duration, and perceptions of crowding.

2.5.2 Ordinal logistic regressions: Influences on frequency, duration, and crowding

First, frequency and percentages were used for the survey data to highlight descriptive results. The chi-squared test was used, similar to the analyses above, to analyze the relationship between the independent and dependent variables. The independent variables tested are transport mode, gender, visible minority member identification, income, park type, day, time, and reason for the visit. The dependent variables are visit frequency, duration, perceived crowding, and perceived crowding by others.

In order to introduce these variables in ordinal logistic regressions, the survey responses are categorized in groups based on whether they are ordinal or nominal and the significant bivariates were introduced as independent variables in ordinal logistic regressions. Ordinal logistic regressions transform the dependent variable and then use Maximum Likelihood Estimation to estimate the parameters. It can describe the relationship between a set of independent variables and an ordinal dependent variable. All computations were done using R software (R Core Team 2021).

In this study, the ordinal responses, frequency of visit, length of visit, and perceived crowding, all have a natural order:

$$frequency = \begin{Bmatrix} 1, rarely \\ 2, occasionally \\ 3, regularly \end{Bmatrix} \qquad duration = \begin{Bmatrix} 1, < 30\ minutes \\ 2, 30\ to\ 60\ minutes \\ 3, > 1\ hour \end{Bmatrix}$$

$$percieved\ crowding\ or\ percieved\ crowding\ by\ others = \begin{Bmatrix} 1, never \\ 2, rarely \\ 3, regularly \end{Bmatrix}$$

The independent variables are park type, time of the day, day of the week, and visit reason. The ordinal logistic regression equation goes as follows: *Y* is the response variable, X_n is the *nth* predictor variable, and B_n is the average effect on *Y* of a one-unit increase in X_n, holding all else constant.

$$p(Y) = e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\ \ldots+\beta_p X_p} / (1 + \ e^{\beta_0+\beta_1 X_1+\beta_2 X_2+\ \ldots+\beta_p X_p}) \tag{5}$$

2.6 Conclusion

This chapter shows the methodological basis of this dissertation, a sequential multi-methods study of parks in Greater Montreal. Primary data on park usage, crowding, and perceptions were collected with the help of several data collection tools based on systematic observations and intercept surveys. Other secondary data sources used to support the primary data are the urban environment, the park design, and the weather. The data structuration combines semi-automatic processes implemented by open software, hence reproducible. Several statistical and visual analyses were chosen to analyze the data, especially the variables of frequency, duration, perception of crowding, and perception by others of crowding in the final stage of analysis. Attention was paid to the categories of variables and the spatial scale of the research at every step.

PART II: PRESENTATION OF RESULTS

CHAPTER 3: ENVIRONMENTAL EQUITY AND ACCESSIBILITY TO PARKS IN GREATER MONTREAL: AN ANALYSIS OF SPATIAL PROXIMITY AND POTENTIAL CONGESTION ISSUES

3.1 Introduction

In the following chapter, the results are in response to the first dissertation objective: *How does the accessibility to parks vary across different population groups (e.g., low-income, visible minorities, children, seniors) in Greater Montreal according to a park's proximity and carrying capacity of park size/equipment?* The results are based on an article published in the Journal of Urbanism: International Research on Placemaking and Urban Sustainability[3] and have been expanded upon for the dissertation. Section 3.2 presents the results of the three potential accessibility measures, and the typologies of spatial accessibility measures by dissemination areas. Then, when diagnosing environmental equity in Section 3.3, the chapter highlights the weighted t-test and regression results. Then, the conclusion highlights the utility of these results in relation to park planning.

At this stage, we use carrying capacity and park size as proxies to assess potential crowding. In line with the E2SFCA method, references to potential park congestion result from the objective typologies of spatial accessibility. Park size determines its carrying capacity, which is the maximum number of visitors it can accommodate, which influences the potential crowding of the park based on the population density it serves. Later in the second research question, we no longer refer to potential congestion since we are now referring to crowding, which we characterize by measuring park visitors' presence and their activities. Furthermore, in the third question, we are using park perception as a proxy for understanding the experience of crowding, drawing inspiration from the concept of functional density. Functional density differs from carrying capacity in that it represents the user experience of crowding rather than an objective measure of potential crowding.

[3] Victoria Jepson, Philippe Apparicio & Thi-Thanh-Hien Pham (2022): Environmental equity and access to parks in Greater Montreal: an analysis of spatial proximity and potential congestion issues, Journal of Urbanism: International Research on Placemaking and Urban Sustainability, DOI: 10.1080/17549175.2022.2150271

3.2 Mapping Access to Parks: Closest Park and Potential Park Congestion

The three potential accessibility measures are mapped at the DA level in Figure 10. Furthermore, Figure 10.b locates the suburban areas of Laval, the North Shore, and the South Shore, and the urban core area of the Island of Montreal. The univariate statistics for these measures and the sociodemographic variables are reported in Table 7.

Figure 10.a clearly shows that the level of spatial accessibility to parks is higher on the Island of Montreal in comparison to the suburban areas of Laval, the North Shore, and the South Shore. Indeed, for most of the DAs on the Island of Montreal, the closest park is within a walking distance of 200 meters. Overall, the univariate statistics demonstrate that accessibility in terms of the closest park is not a pronounced issue in the Greater Montreal area, given that the mean and median values are 314 and 250 meters, respectively (Table 7). Only 5% of 6031 DAs have the closest park higher than 652 meters (P95, Table 7).

Figures 11.c and 11.d present the potential park area congestion and potential park facility congestion by DAs, respectively. Both maps show a lower level of potential congestion in the suburban areas and a higher level in the inner city of Montreal. In Greater Montreal, the mean values are 7.5 hectares and 6.6 facilities per 1000 inhabitants (median: 3.8 and 5.1), indicating one hectare per 133 people and one facility per 151 people.

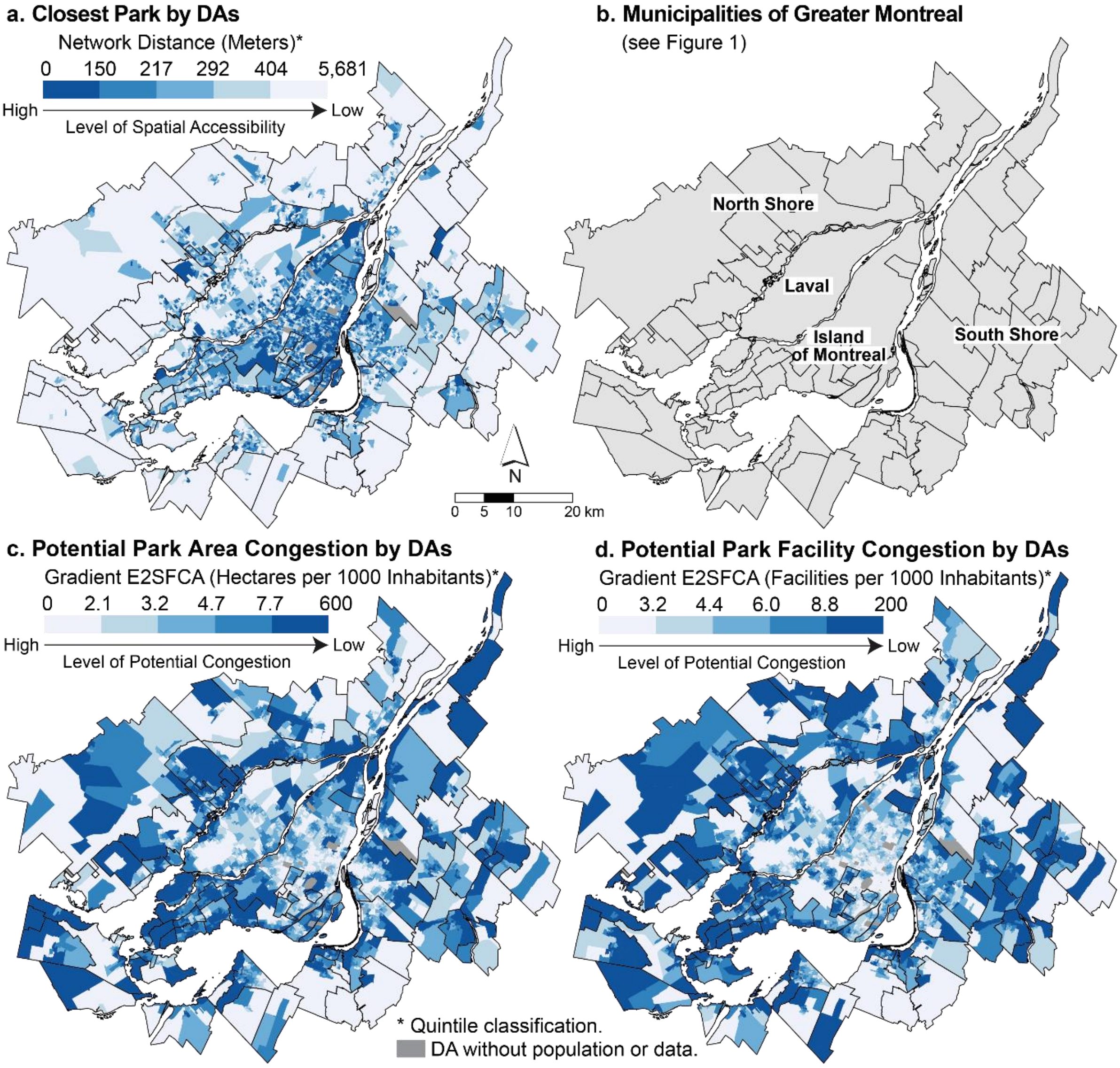


Figure 10. Spatial accessibility measures by dissemination areas.

Table 7. Univariate statistics for the sociodemographic variables and accessibility measures.

Variables	Mean	STD	P5	Q1	Q2	Q3	P95	Moran's I
Sociodemographic indicators								
Density (inhabitants/ha)	7038	7263	495	2781	4477	9760	19217	0.517
0-14 years old (%)	16.4	5.1	8.3	13.4	16.2	19.2	25.1	0.464
65 years old and over (%)	16.3	9.3	5.7	10.3	14.8	19.9	31.7	0.314
Low-income population (%)	12.6	10.5	1.4	4.1	9.8	18.7	32.6	0.679
Visible minorities (%)	23.3	19.3	0.9	8.2	18.3	34.0	62.2	0.754
Accessibility measures								
Closest Park (meters)	314	332	74	167	250	370	652	0.444
E2SFCA (hectares)	7.5	21.4	1.1	2.3	3.8	6.7	20.0	0.314
E2SFCA (services)	6.6	7.2	1.8	3.5	5.1	7.8	15.5	0.271

N = 6031. STD: standard deviation; P5: 5th percentile; Q1: lower quartile; Q2: median; Q3: upper quartile; P95: 95th percentile. Moran's I calculated with a rook matrix (first order of contiguity); all Moran's I values are significant at $p < 0.001$ (using 999 random permutations).

In summary, inhabitants in urban core Greater Montreal, namely the City of Montreal, seem to live closer to a park with higher potential congestion. Inversely, those on the outskirts live further from a park but with lower potential congestion. This demonstrates the importance of simultaneously analyzing the closest park and E2SFCA measures to provide a more comprehensive picture of park access. In doing so, the quintile cross-tabulations of these measures are mapped in Figure 11.

The first typology presents the cross-tabulation of the closest park and potential park area congestion (Figure 11.a). The second typology is done with the closest park and potential park facility congestion (Figure 11.b). In each of the typologies, DAs are classified into nine categories. The x-axis represents, left to right, high levels of accessibility (favorable) to low levels of accessibility (unfavorable), and the y-axis denotes low levels of either potential park area or facility congestion (favorable) to high levels of potential congestion (unfavorable). The two categories in green are characterized by high levels of accessibility and low levels of potential park congestion, denoting a favorable park access situation. Meanwhile, DAs with low accessibility and high potential congestion are found in gray categories, denoting an unfavorable situation. Between these two extremes, three distinct park access situations can be identified: 1) in red, low levels of accessibility and low to medium potential park congestion; 2) in blue, high to medium levels of accessibility and high potential park congestion; 3) in yellow, medium levels of both accessibility and potential park congestion.

Maps in Figure 11 reveal that the two typologies hold similar tendencies. First, DAs with high levels of accessibility and high levels of potential congestion are primarily found in Montreal's inner city and some areas in Laval (in blue). Second, DAs with low levels of accessibility and low to medium potential congestion are mainly located in the suburban areas of the South and North Shore (in red). Third, DAs characterized by unfavorable park access—low level of accessibility and high level of park congestion (in gray)—are mainly found in the North and

South Shore and Laval. Fourth, DAs in green (the most favorable access) and yellow (medium access) are dispersed throughout Greater Montreal, with the green DAs more localized.

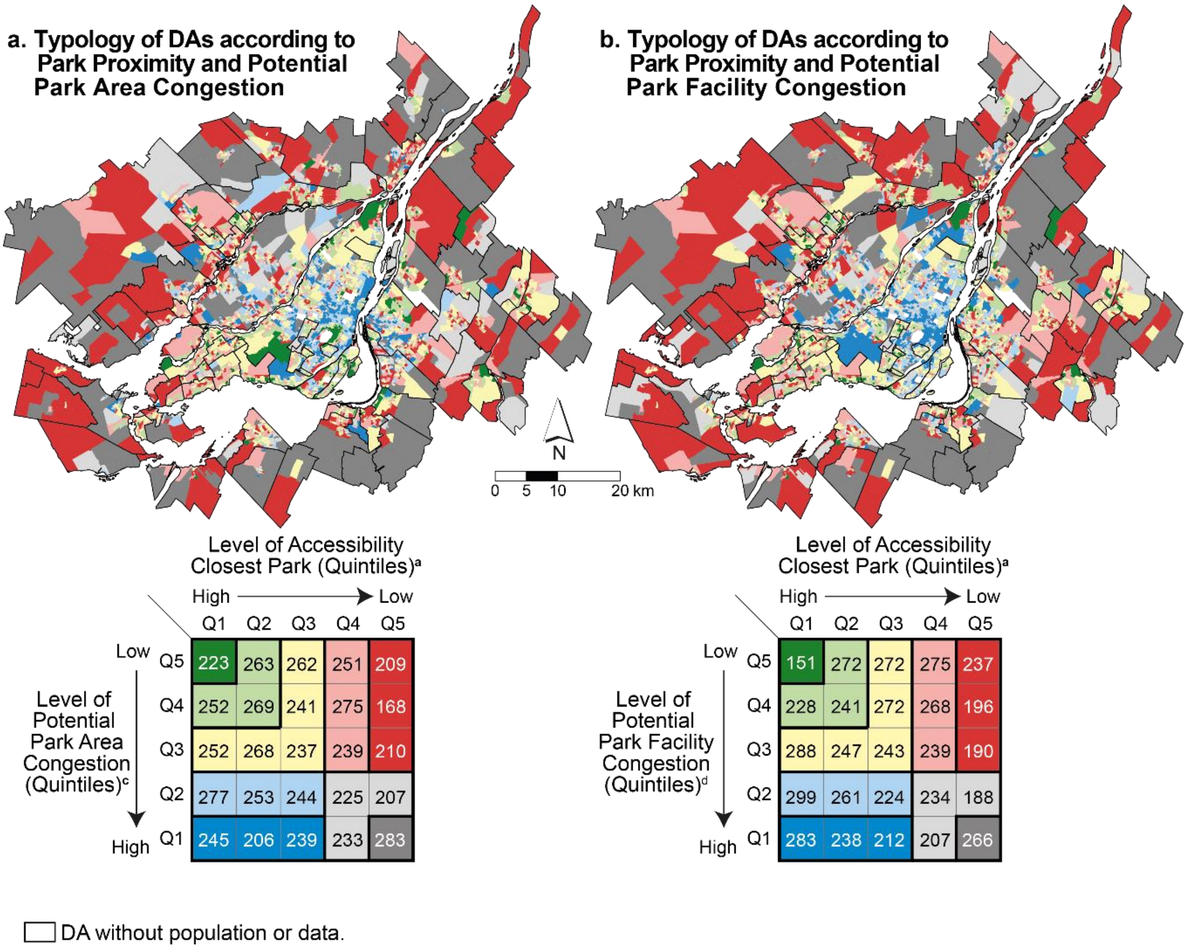


Figure 11. Typologies of spatial accessibility measures by dissemination areas.

[a., c., d.:] See respectively Figures 10.a, 10.c., and 10.d. Reported numbers are DA counts for each cross-tabulation cell.

3.3 Diagnosing Environmental Equity

3.3.1 Comparing Means for the Selected Groups and the Rest of the Population (Weighted t-test results)

Table 8 shows that seniors do not seem to have differential access to parks compared to the rest of the population (mean distances to park = 314 m and 325 m, p = 0.058). As for the three other groups, the differences in the closest park measure are significant, but they remain relatively weak. For example, children under 15 live on average 333 meters away from the closest park versus 321 meters for the rest of the population; this extremely small difference of 12 meters cannot be considered an environmental inequity. In contrast, low-income individuals and visible minorities live closer to a park than the rest (−78 and −66 meters, respectively).

However, there is a different portrait of environmental equity regarding park congestion: both low-income individuals and visible minorities live in areas with higher potential park areas and facility congestion. For example, significant differences were found for visible minorities: 5.73 hectares and 5.35 facilities per 1000 people versus 8.31 and 6.93 for the rest of the population. Finally, there are no significant differences for children and seniors.

Table 8. Means of accessibility measures for the four groups studied and the rest of the population (weighted t-test).

		Closest Park (meters)				E2SFCA (hectares)			
		Mean		Difference		Mean		Difference	
Group 1 (G1)	Group 2 (G2)	G1	G2	Diff	P	G1	G2	Diff	P
0–14 years old	>15 years old	333	321	12	0.034	7.67	7.70	−0.03	0.934
>=65 years old	<65 years old	314	325	−11	0.058	7.79	7.67	0.12	0.774
Low-income pop.	No low-income pop.	255	333	−78	0.000	5.37	8.00	−2.63	0.000
Visible minorities	No visible minorities	273	339	−66	0.000	5.73	8.31	−2.58	0.000
		E2SFCA (facilities)							
0–14 years old	>15 years old	6.60	6.56	−0.04	0.817				
>=65 years old	<65 years old	6.90	6.50	0.40	0.019				
Low-income pop.	No low-income pop.	5.19	6.74	−1.55	0.000				
Visible minorities	No visible minorities	5.35	6.93	−1.58	0.000				

3.3.2 Regression results for the three accessibility measures

The results of the three GLM models with log-normal distributions are reported in Table 9. A low closest park value means better spatial accessibility, whereas a lower value for the two E2SFCA means higher potential park congestion. A positive coefficient for model A (closest park) and a negative coefficient for models B and C (potential park congestion) reveal a potential environmental inequity for the population group.

Table 9. Results of GLM models with log normal distribution.

Dependent variable	**Model A** Closest Park (meters)		**Model B** E2SFCA (hectares)		**Model C** E2SFCA (facilities)	
	Coef.	P	Coef.	P	Coef.	P
Intercept	5.737	<.0001	1.948	<.0001	1.756	<.0001
0-14 years old (%)	0.007	0.004	−0.001	0.589	0.016	<.0001
65 years old and over (%)	−0.003	0.004	0.003	0.004	0.008	<.0001
Low-income population (%)	−0.020	<.0001	−0.013	<.0001	−0.010	<.0001
Visible minorities (%)	−0.002	<.0001	−0.005	<.0001	−0.006	<.0001
R^2 (Nagelkerke)	0.1054		0.1063		0.2148	
AIC	79260		33315		31003	

Model A shows that the percentage of children is positively associated with accessibility to the closest park, but the regression coefficient is very weak (β=0.007, p=0.004). This suggests the higher percentage of children there is, the further the parks are. Inversely, for the three other population groups—65 years old and over, low-income individuals, and visible minorities—all coefficients are significantly negative (β = −0.003, −0.020, and −0.002). This means that these three population groups, particularly low-income individuals, are in a favorable situation regarding park proximity.

In terms of park congestion, the coefficients of the low-income population and visible minorities percentages are significantly negative for models B and C (β = −0.013, −0.010, and −0.005, −0.006, respectively), denoting environmental inequities. This corroborates the t-test results.

To further illustrate these findings, marginal effects are presented in Figure 12. For the closest park model (A), the y-axis shows small variations for the children, seniors, and visible minorities (Figure 12.a). For example, the distance to the closest park varies from 275 to 325 meters when the percentage of children varies from 0 to 25. This means that there is not much difference between distance of the park and the percentage of children. In contrast, greater variations are noted for the low-income population: from 400 to 200 meters, respectively, for a range of 0 to 35 percent. Similar patterns, i.e., the low-income population having greater park access variations than the three other groups, are also observed for the two park congestion models (Figure 12.b and c). This means that there is a difference of about two facilities when the percentage of low-income population grows. In sum, the seniors enjoy the most favorable situations both in terms of the distance to parks and the congestion.

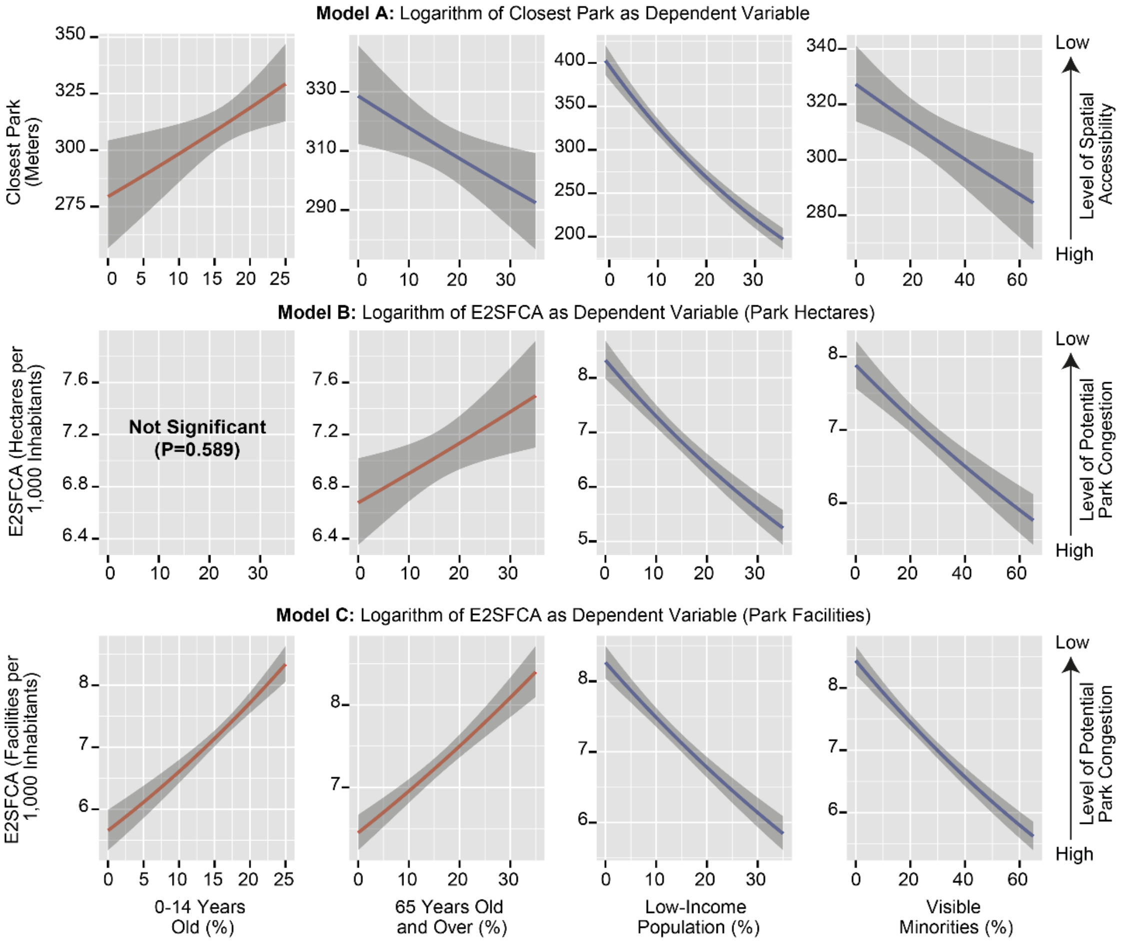


Figure 12. Marginal effects of the four population group percentages for the three GLM models with log normal distribution.

The two multinomial logistic regression models are built with the yellow category (medium levels of both accessibility and potential park congestion) as the reference category (see Figure 11 for categories). These models (Table 10 and 11) are used to determine whether the percentage of each of the four population groups significantly increases or decreases the probability that the dissemination area belongs to one of the categories in the cross-tabulations compared to the yellow category.

Table 10. Multinomial logistic regression (Dependent variable: Typology of DAs according to park proximity and potential park area congestion, reference category: Yellow).

Category [a]	Coef.	OR[b]	OR (97.5%[c])		P	Coef.	OR[b]	OR (97.5%[c])		P
	0-14 years old (%)					65 years old and over (%)				
Green	−0.057	0.945	0.909	0.981	0.003	−0.007	0.993	0.978	1.008	0.343
Light Green	−0.007	0.993	0.970	1.016	0.530	−0.006	0.994	0.984	1.005	0.301
Light Red	−0.018	0.982	0.959	1.006	0.134	−0.013	0.987	0.975	0.998	0.023
Red	−0.005	0.995	0.969	1.022	0.715	−0.014	0.986	0.973	0.999	0.036
Light Blue	−0.050	0.951	0.930	0.973	0.000	−0.026	0.975	0.964	0.986	0.000
Blue	−0.029	0.971	0.949	0.993	0.011	−0.048	0.953	0.940	0.966	0.000
Light Gray	0.008	1.008	0.985	1.032	0.480	−0.025	0.975	0.963	0.988	0.000
Gray	−0.012	0.988	0.955	1.022	0.489	−0.031	0.970	0.951	0.989	0.002
	Low-income population (%)					Visible minorities (%)				
Green	0.024	1.024	1.007	1.042	0.006	−0.008	0.992	0.982	1.002	0.101
Light Green	0.006	1.006	0.994	1.017	0.327	−0.012	0.988	0.982	0.994	0.000
Light Red	−0.040	0.960	0.948	0.973	0.000	0.001	1.001	0.995	1.007	0.679
Red	−0.067	0.936	0.921	0.951	0.000	−0.014	0.986	0.979	0.993	0.000
Light Blue	0.028	1.029	1.018	1.040	0.000	0.007	1.007	1.001	1.012	0.022
Blue	0.052	1.053	1.041	1.064	0.000	0.007	1.007	1.001	1.013	0.027
Light Gray	−0.001	0.999	0.987	1.011	0.905	0.002	1.002	0.996	1.008	0.466
Gray	−0.065	0.937	0.918	0.957	0.000	−0.002	0.998	0.990	1.007	0.702
AIC	24421									
R^2 (Cox & Snell)	0.1531									
R^2 (Nagelkerke)	0.1554									

[a] See the categories in Figure 11. Reference category: Yellow. [b] Odds ratio. [c] 95% Wald confidence limits.

Table 10 first present the multinomial logistic regression with the typology of DAs according to park proximity and potential park area congestion. Concerning children, the odds ratios are less than 1 for the Green, Light Blue, and Blue categories (Table 10). This suggests that DAs with a higher percentage of children have less chance to be in these categories categorized by favorable park area congestion or high to medium levels of accessibility and high potential park area congestion.

There is a more favorable situation for seniors (Table 10). All other things being equal, an increase in the percentage of seniors reduces the probability of their DA belonging to any other category expect for Green and Light Green (which are the two favorable categories). This means that DAs that have a higher percentage of seniors have less chance of being in Light Red, Red, Light Blue, Blue, Light Gray, and Gray categories.

For the low-income population group, it is not as straightforward. Its percentage is associated with a decreased probability of their DAs belonging to Light Red and Red (low proximity and low congestion), and Gray (low proximity and high congestion, i.e., the least favorable category). However, there is an increased probability that their DAs belong to Green (high spatial proximity and low level of potential park area congestion), as well as Light Blue and Blue, two categories that are quite undesirable (high to medium levels of spatial accessibility and high levels of potential park area congestion).

Lastly, the situation for the population percentage of persons belonging to a visible minority is the most unfavorable. An increase in the percentage of visible minorities decreases the probability of their DAs belonging to Light Green (high spatial accessibility and low potential area congestion) and Red (low spatial accessibility and low to medium potential facility congestion). It also increases the probability of belonging to Light Blue and Blue which are undesirable (high to medium levels of spatial accessibility and high levels of potential park area congestion).

Though the results of the two models are pretty similar, the AIC and R-squared values show that the potential park facility model (Table 11) performs slightly better than the park area model (Table 10). The differences are highlighted between the two tables; however, we prioritize interpreting the park facility model (Table 11) and report its marginal effects (Figure 13) as it is the most significant.

Table 11. Multinomial logistic regression (Dependent variable: Typology of DAs according to park proximity and potential park facility congestion, reference category: Yellow).

Category [a]	Coef.	OR[b]	OR (97.5%[c])		P	Coef.	OR[b]	OR (97.5%[c])		P
	0-14 years old (%)					65 years old and over (%)				
Green	0.022	1.022	0.979	1.068	0.326	0.020	1.020	1.002	1.039	0.033
Light Green	0.020	1.020	0.997	1.044	0.087	0.009	1.009	0.998	1.020	0.106
Light Red	0.004	1.004	0.981	1.028	0.723	−0.005	0.995	0.984	1.007	0.436
Red	0.004	1.004	0.979	1.030	0.744	−0.009	0.991	0.978	1.004	0.174
Light Blue	−0.049	0.952	0.931	0.974	0.000	−0.017	0.983	0.972	0.994	0.002
Blue	−0.105	0.900	0.879	0.921	0.000	−0.044	0.957	0.945	0.969	0.000
Light Gray	−0.033	0.968	0.945	0.992	0.009	−0.023	0.977	0.965	0.990	0.000
Gray	−0.012	0.988	0.954	1.024	0.520	−0.027	0.974	0.954	0.993	0.009
	Low-income population (%)					Visible minorities (%)				
Green	−0.016	0.984	0.962	1.007	0.172	−0.014	0.986	0.974	0.999	0.032
Light Green	−0.031	0.970	0.958	0.982	0.000	0.002	1.002	0.996	1.008	0.487
Light Red	−0.057	0.945	0.933	0.957	0.000	0.004	1.004	0.998	1.010	0.185
Red	−0.075	0.928	0.913	0.942	0.000	−0.016	0.984	0.977	0.991	0.000
Light Blue	0.024	1.025	1.014	1.035	0.000	0.013	1.013	1.008	1.019	0.000
Blue	0.026	1.027	1.016	1.038	0.000	0.025	1.025	1.019	1.031	0.000
Light Gray	−0.015	0.985	0.974	0.997	0.013	0.018	1.018	1.012	1.024	0.000
Gray	−0.082	0.921	0.902	0.941	0.000	0.010	1.010	1.001	1.019	0.027
AIC	23856									
R^2 (Cox & Snell)	0.1908									
R^2 (Nagelkerke)	0.1938									

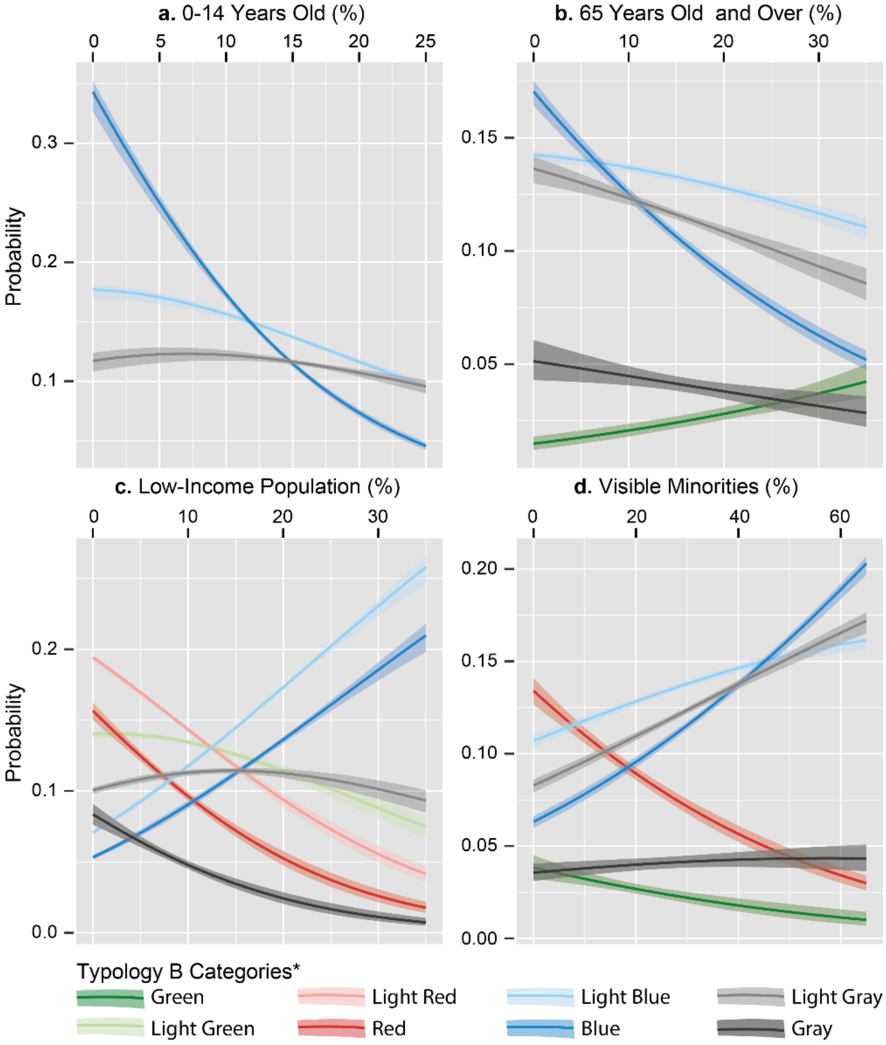
[a] See the categories in Figure 11. Reference category: Yellow. [b] Odds ratio. [c] 95% Wald confidence limits.

Concerning children, only three categories are significant with odds ratios less than 1. All other things being equal, an increase in the percentage of children reduces the probability of their residential DA belonging to Light Blue, Blue, and Light Gray categories, characterized by high park facility congestion, no matter the level of spatial accessibility (Table 11 and Figure 13.a). This slightly different than the park area congestion model as the Green (the most favorable) is not present here.

The situation remains favorable for seniors (Table 11 and Figure 13.b): odds ratios are less than 1 for the Light Blue, Blue, Light Gray, and Gray categories and higher than one for the Green category (which represents the best situation with high spatial accessibility and low potential park facility congestion). This suggests DAs that have a higher percentage of seniors have more chance to be in the green category and less chance to be in blue or gray.

The situation remains much more nuanced for the low-income population group. On the one hand, its percentage is associated with a decreased probability of their DAs belonging to Light Green (high spatial proximity and low level of potential park facility congestion), Light Red and Red (low proximity and low congestion), and Light Gray and Gray (low proximity and high congestion, i.e., the least favorable category). On the other hand, there is an increased probability that their DAs belong to Light Blue and Blue, two categories that are quite undesirable (high to medium levels of spatial accessibility and high levels of potential park facility congestion).

Finally, the situation for the population percentage of persons belonging to a visible minority remains the most unfavorable. As shown in Figure 13.d, an increase in the percentage of visible minorities decreases the probability of their DAs belonging to Green (high spatial accessibility and low potential facility congestion) but also Red (low spatial accessibility and low to medium potential facility congestion). It also increases the probability of belonging to Light Blue, Blue, Light Gray, and Gray, all of which have high potential park facility congestion no matter the level of spatial accessibility. It should be noted that the population percentage of visible minorities is the only group positively associated with the two less favorable categories (Gray and Light Gray) characterized by low accessibility and high potential park facility congestion.



* See Figure 3.b and Table 4 in the article. Note only the marginal effects for the significant coefficients (at p=0.05) are plotted.

Figure 13. Marginal effects of the four population group percentages for the multinomial model with Typology B (Park proximity and potential park facility congestion).

3.4 Conclusion

These findings support the relevance of using multiple accessibility measures in park planning that consider two dimensions of park access, i.e., park proximity and potential park congestion. Geographically speaking, our findings demonstrate that urban core neighborhoods have higher potential park area and facility congestion compared to suburban municipalities. This chapter resulted in the DAs with significant percentage of children seem to have father away park far from residential areas and more congested in terms of facilities. Moreover, seniors do not seem to be associated with any problems of accessibility. Last, the accessibility situation for low-income individuals is more complex concerning both typologies.

CHAPTER 4: PARK CROWDING ACROSS A METROPOLITAN REGION IN GREATER MONTREAL PARKS

4.1 Introduction

The following chapter presents the results of the dissertation' second objective: *How does park crowding differ in the function of park profiles and usage patterns?* As in the previous chapter, the results are based on an article published in the *Canadian Journal of Urban Research*[4] have been expanded upon for the dissertation. The following sections present the results of the GIS-based observational method used to examine crowding in different types of parks. Section 4.2. focuses on the spatial dimensions of park use and crowding, Section 4.3. on the temporal dimension of park use crowding, and lastly, Section 4.4. on park use according to age group and group size.

For this second objective, potential congestion is no longer utilized. We are now referring to crowding, which we characterize by measuring park visitors' presence and their activities, both temporally and spatially, within the park perimeters. We are looking at the number of visitors throughout time and the park space. This second objective is set to consider the spatial patterns of users in comparison to the objective results of E2SFCA and the previous environmental equity assessment.

4.2 Spatial Dimension of Park Use and Crowding

During the 108 hours of observation, 1588 observations, i.e., points of users, were collected in the six parks[5]. Up to three activities could be recorded per single visitor or group, resulting in 1,282 observations with one activity (80.7%), 276 with two activities (17.4%), and 30 with three activities (1.89%), with a total of 1,924 activities. This means that people changed activities within a period of time when visiting the park. The most recorded activities were passive activity (41.8%), playgrounds (19.8%), and free play (10.4%) (Table 12). The chi-

[4] Jepson, Victoria, Thi-Thanh-Hien Pham, and Philippe Apparicio. (2023). Exploring park crowding across a metropolitan region using a GIS-based observational methodology: The case of six Greater Montreal parks. Canadian Journal of Urban Research, 32(2), 78-98.

[5] Parc Bariteau, parc Bourbonnière, parc de Bucarest, parc Chamberland, parc Hochelaga, parc Wilson.

square test shows a significant association between the six parks and 12 activities ($\chi2(55, N = 1924) = 1281$, $p < 0.001$), highlighting the association between type of park and design.

Unsurprisingly, the three parks located in suburban areas (Bucarest, Bourbonnière, and Bariteau) have the lowest frequencies of park observations (64, 149, and 209), whereas three other parks in the City of Montréal (Chamberland, Wilson, Hochelaga) have the highest (553, 473, and 476).

Even though passive activity is the most observed activity overall (41.8%), it varies significantly according to the six parks along the urban-suburban axis. It is overrepresented in Hochelaga (67.6%), Bariteau (44.0%), de Bucarest (40.6%), and Chamberland (40.0%), and on the contrary, underrepresented in Bourbonnière (6.0%). The same applies to playground use, which varies from less than 10% (Bourbonnière and de Bucarest) to 34.2% of visitors (Wilson). While all parks have playgrounds, Wilson has the highest percentage of playground use out of the six parks. The high percentage of playground use is Bariteau is due to a daycare located next to the park. Otherwise, the two other suburban parks have low percentages of playground use. In the two parks that have tennis and/or pickleball courts, Bourbonnière and Wilson, these facilities are also well visited (45.0% and 17.5%, respectively).

Table 12. Contingency table between activity types and parks.

	Frequencies per park							Percentages per park						
	Suburban			Urban Core				Suburban			Urban Core			
Activity	BO	BU	BA	CH	WI	HO	All	BO	BU	BA	CH	WI	HO	All
Passive activity	9	26	92	221	135	322	805	6.0	40.6	44.0	40.0	28.5	67.6	41.8
Music	2	0	6	0	2	3	13	1.3	0.0	2.9	0.0	0.4	0.6	0.7
Walking a dog	2	10	3	0	4	6	25	1.3	15.6	1.4	0.0	0.8	1.3	1.3
Playground	13	6	50	69	162	81	381	8.7	9.4	23.9	12.5	34.2	17.0	19.8
Water play area	0	0	23	13	5	25	66	0.0	0.0	11.0	2.4	1.1	5.3	3.4
Free play	3	18	16	85	64	14	200	2.0	28.1	7.7	15.4	13.5	2.9	10.4
Exercise	1	3	7	58	10	7	86	0.7	4.7	3.3	10.5	2.1	1.5	4.5
Baseball	19	0	0	11	0	0	30	12.8	0.0	0.0	2.0	0.0	0.0	1.6
Basketball	13	0	3	54	0	0	70	8.7	0.0	1.4	9.8	0.0	0.0	3.6
Tennis or pickleball	67	0	0	0	83	0	150	45.0	0.0	0.0	0.0	17.5	0.0	7.8
Other sport games	1	0	3	3	4	8	19	0.7	0.0	1.4	0.5	0.8	1.7	1.0
Other	19	1	6	39	4	10	79	12.8	1.6	2.9	7.1	0.8	2.1	4.2
Total	149	64	209	553	473	476	1924							
%	7.7	3.3	10.9	28.7	24.6	24.7	100.0							

BA: parc Bariteau; BO: parc Bourbonnière; BU: parc de Bucarest; CH: parc Chamberland; HO: parc Hochelaga; WI : parc Wilson.

Maps of activity types (Figure 14) reveal different spatial crowding patterns within each park along the urban-suburban axes. First, in the urban core, Hochelaga clearly has two distinct spatial patterns (Figure 14.e): a concentration of users in the playground area in the east part (light purple dots) and a large concentration of users in the rest of the park, of which the majority is passive activity. Second, the spatial patterns of users in Wilson and Chamberland show an overlapping of different activities throughout the parks (i.e., playground users, passive activities, and free play), with only a tiny part that is not frequently used, e.g., the baseball field of Chamberland and the open green space in Wilson (Figure 14.d and f). In summary, there is a much higher level of users for these three urban core parks during the period of observation. Recall that these parks are located in a DA characterized by a high level of park proximity (Table 3 in Chapter 2).

Inversely, the three other suburban parks have rather dispersed spatial patterns, suggesting low usage and crowding. With this being said, the three suburban parks also show different spatial patterns. There is no activity overlapping in Bourbonnière; in other words, each part of the park is used for a specific activity (tennis, basketball, baseball, and the playground). Bariteau has little activity diversity: playground use and passive activity are mainly concentrated around the playground area. In Bucarest, only 64 observations are scattered and not even close to its three playground areas (Figure 14.d). For this reason, Bucarest is not retained for the other visual analyses. This finding confirms the typology of park proximity and congestion (Table 3) used to select the parks, i.e., the fact that people live far from a park and the low density of population around a park explains why the park is less used.

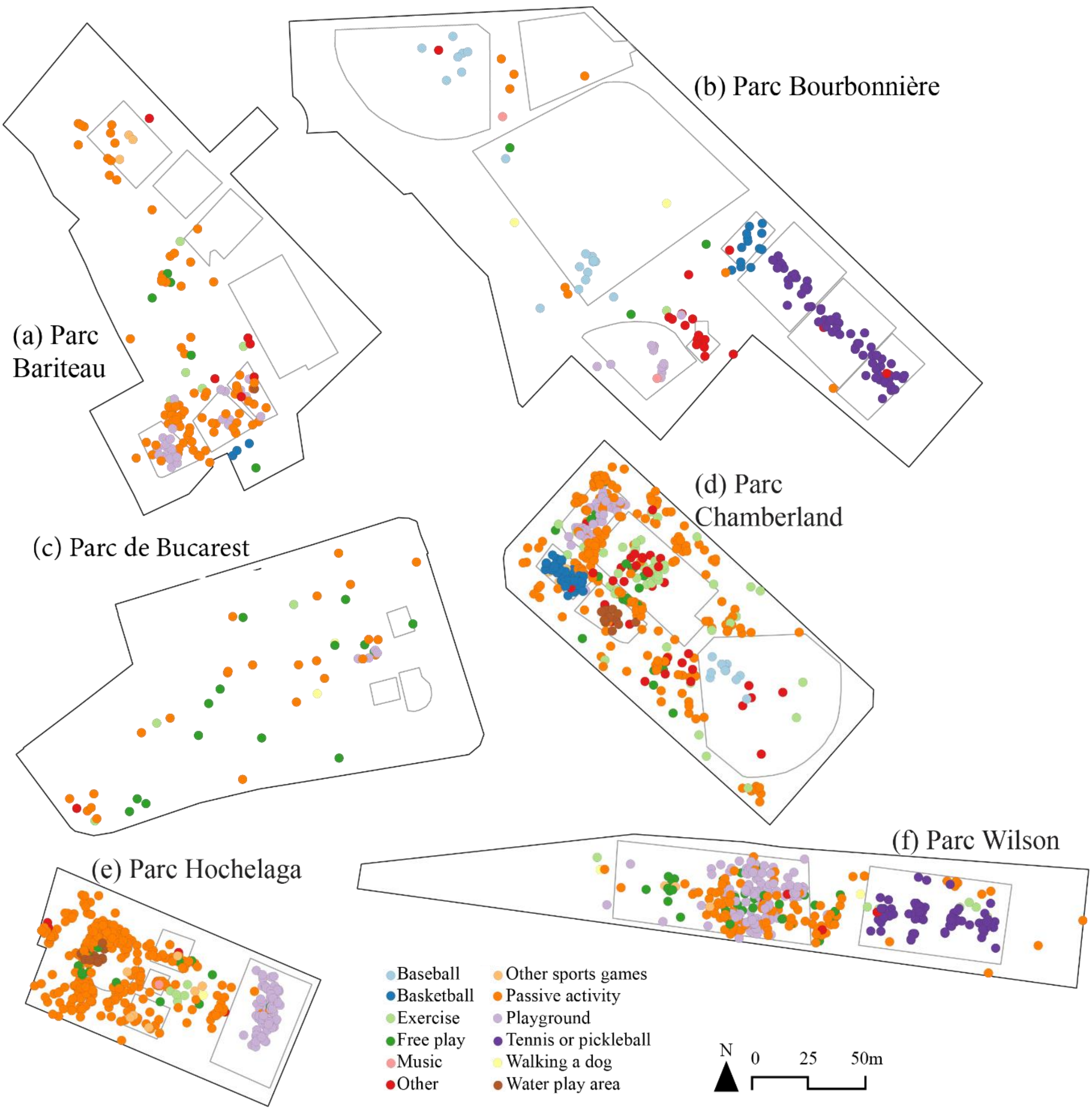


Figure 14. Activity types in the six parks.

All main findings are illustrated in figures, however, for each crowding variable (activity type, day of week, period, age group, and group size), we only report the kernel density estimations of two parks to illustrate (dis)similarities in the park use spatial patterns (Table 13).

Correlations of kernel density maps show that Hochelaga and Bourbonnière are the two parks that have the most dissimilarities between active and passive activity spatial patterns with $r = 0.200$ ($p < 0.001$) and $r = -0.009$ ($p = 0.074$), respectively (Table 13). The Pearson correlation values are calculated between the kernel densities estimations modalities of each qualitative variables (day of the week, time period, age group and type of activity). Higher the correlation value between two kernel density maps, the higher spatial patterns are similar. If a qualitative variable contains more than two modalities (i.e. morning, afternoon and evening for the time period), the arithmetic mean of the correlation values is calculated. In the same way, the higher the arithmetic mean, the more spatial patterns for the different modalities of a given dimension are similar. The use of the geometric mean was preferred to the arithmetic mean because it is less sensitive to extreme values.

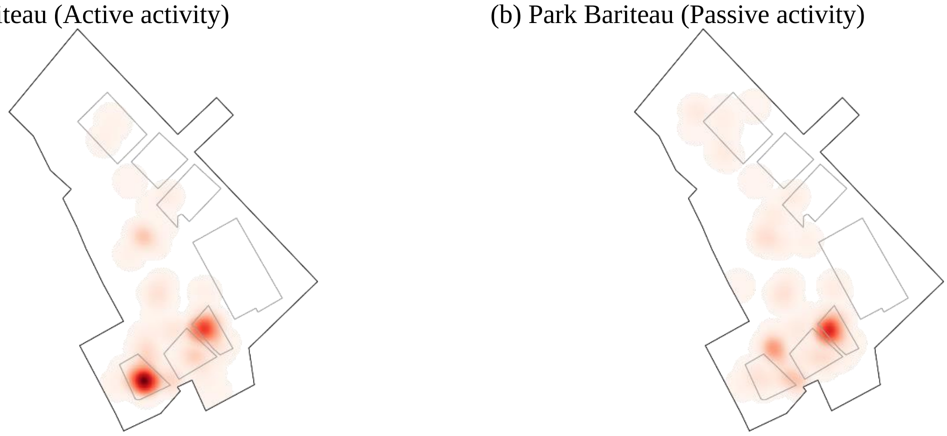
Table 13. Pearson's correlation coefficient between the kernel density estimations.

Dimension	Variable 1	Variable 2	BA	BO	CH	HO	WI
Type of activity	Active activity	Passive activity	0.646	-0.009	0.788	0.200	0.533
Time period	Weekday	Weekend	0.751	0.105	0.454	0.847	0.723
	Morning	Afternoon	0.477	0.098	0.640	0.864	0.530
	Morning	Evening	0.762	0.710	0.517	0.878	0.669
	Afternoon	Evening	0.194	0.135	0.691	0.949	0.700
		Geometric mean	0.413	0.211	0.611	0.896	0.628
Age group	0-14 years old	15-24 years old	0.365	0.057	0.536	0.186	0.272
	0-14 years old	25-65 years old	0.915	0.558	0.770	0.736	0.773
	0-14 years old	>65 years old	0.329	0.303	0.241	0.586	0.274
	15-24 years old	25-65 years old	0.352	-0.012	0.402	0.338	0.629
	15-24 years old	>65 years old	0.412	-0.045	0.498	0.140	0.520
	25-65 years old	>65 years old	0.489	0.077	0.347	0.592	0.629
		Geometric mean	0.445	0.116*	0.436	0.362	0.477

BA: parc Bariteau; BO: parc Bourbonnière; BU: parc de Bucarest; CH: parc Chamberland; HO: parc Hochelaga; WI : parc Wilson.
*The arithmetic mean is reported since the geometric mean cannot be computed with negative values.

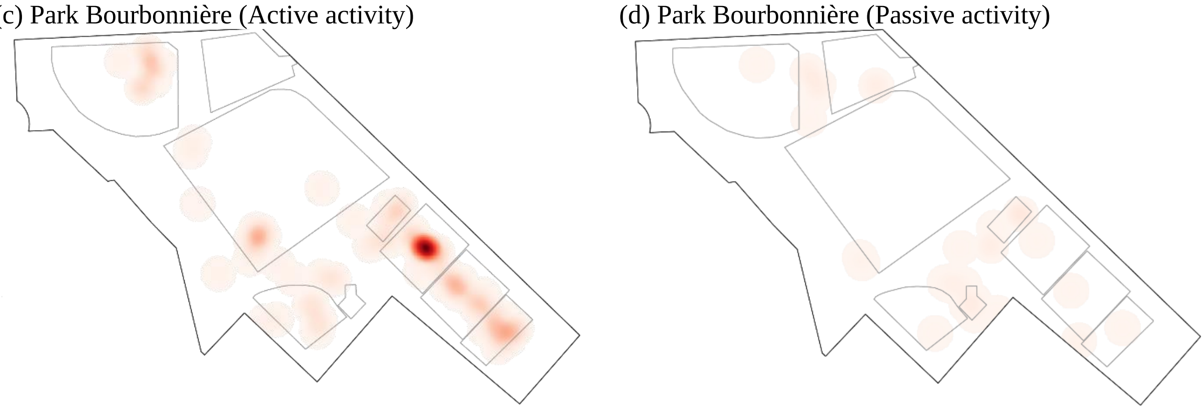
Dissimilarities in Hochelaga and Bourbonnière are explained by two different spatial patterns of usage. We note that in Bourbonnière (c and d in Figure 15), there is a higher density of active activity around the sports fields (e.g., tennis, baseball, and basketball), while passive activity occurs very minimally around the park. In Hochelaga, active activities are concentrated around the playground, while passive activities are spread out throughout the park area. There is low diversity of facilities in Hochelaga, which could explain why everyone is concentrated in the playground and the higher passive activity rates. In the four other parks, Bariteau (a and b in Figure 15) has a lower correlation than Bourbonnière because of parents accompanying children at the playground or water play areas, especially after the daycare lets out. As for the other urban core parks having lower correlations than Hochelaga, their similarities are due to the number and type of facilities found in the parks. Chamberland has a total of five different active activity facilities, and while Wilson has only two, its playground contains diverse equipment appropriate for toddlers and young children, accompanied by swings and various seating arrangements often used by parents and for kids’ birthdays. The diverse facilities within the parks increase the number of activities and result in a more extensive mix of uses.

(a) Park Bariteau (Active activity) (b) Park Bariteau (Passive activity)



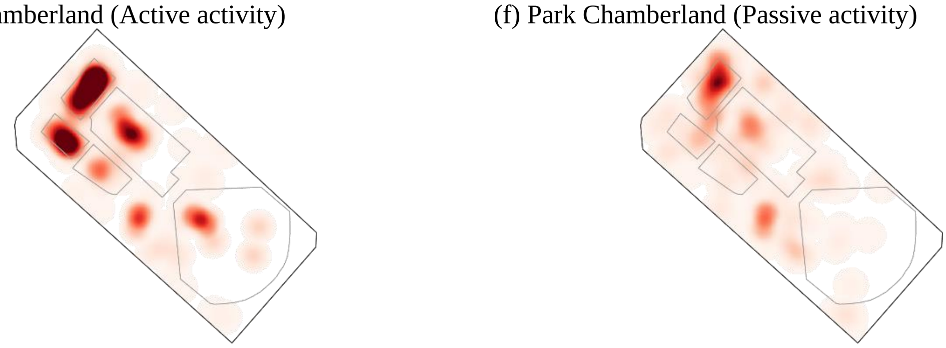
Note: Pearson's correlation between the two kernel density estimations: 0.646.

(c) Park Bourbonnière (Active activity) (d) Park Bourbonnière (Passive activity)



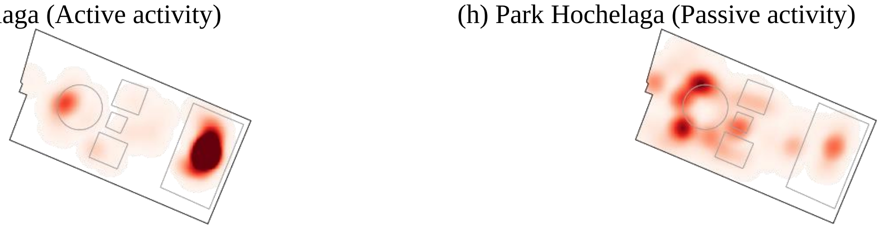
Note: Pearson's correlation between the two kernel density estimations: -0.009.

(e) Park Chamberland (Active activity) (f) Park Chamberland (Passive activity)



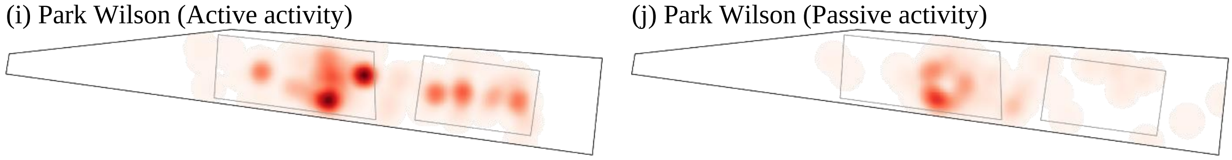
Note: Pearson's correlation between the two kernel density estimations: 0.788.

(g) Park Hochelaga (Active activity) (h) Park Hochelaga (Passive activity)



Note: Pearson's correlation between the two kernel density estimations:0.200.

(i) Park Wilson (Active activity) (j) Park Wilson (Passive activity)



Note: Pearson's correlation between the two kernel density estimations: 0.533.

Figure 15. Density mapping for active and passive activities.

4.3 Temporal Dimension of Park Use and Crowding

The chi-square test of independence reveals there are significant associations between the six parks and two temporal variables with $p < 0.001$: the day of the week with $\chi 2(5, N = 1588) = 37.6$ and the time period of the day (i.e., morning, afternoon and evening) with $\chi 2(10, N = 1588) = 47.1$. This highlights the possibility of temporal variables predicting frequencies. Table 14 shows that Bariteau is the park with the most difference in usage between weekdays and weekends (62.8% and 37.2%) (Table 14). This may be explained by the fact that although it is a suburban park, it is located next to a daycare, and, as a result, there is more use during the weekdays. In contrast, a typical suburban park located in a residential zone, such as Bucarest, has the most observed users during the weekend (68.8%). As for urban-core parks, their usage during the whole week varies slightly between 45% and 55% (Wilson and Hochelaga), with Chamberland having a higher usage on the weekend. For the suburban parks, weekday usage varies between 31.3% to 62.8% and 37.2% to 68.8% during the weekend, depicting quite different fluctuations during the week in park use compared to the urban core parks.

Table 14. Contingency table between days of the week and parks.

	Frequencies per park						Percentages per park						
	Suburban			Urban Core			Suburban			Urban Core			
Day of the week	BO	BU	BA	CH	WI	HO	BO	BU	BA	CH	WI	HO	All
Weekday[a]	60	15	86	178	169	244	41.1	31.3	62.8	41.0	45.0	54.6	47.4
Weekend[b]	86	33	51	256	207	203	58.9	68.8	37.2	59.0	55.1	45.4	52.6

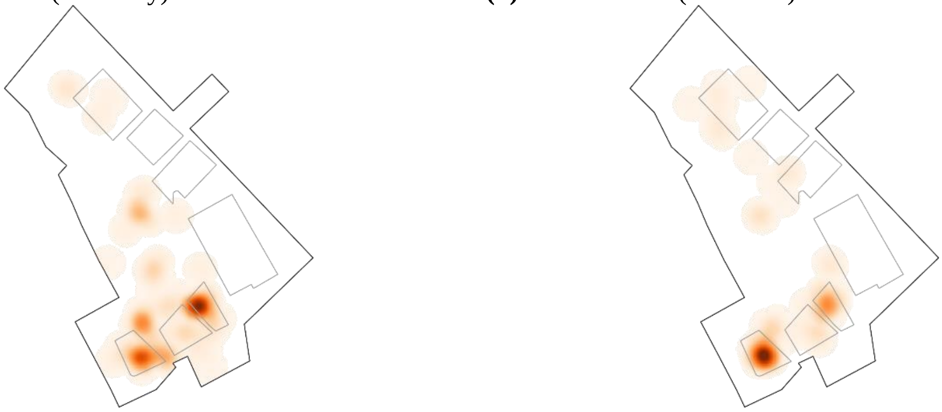
[a] Monday, Tuesday, and Wednesday. [b] Friday evening, Saturday, and Sunday. BA: parc Bariteau; BO: parc Bourbonnière; BU: parc de Bucarest; CH: parc Chamberland; HO: parc Hochelaga; WI : parc Wilson.

The correlation coefficients between the kernel density of weekday and weekend show another picture in Bourbonnière (c and d in Figure 16) and add new insight into our understanding of Chamberland (e and f in Figure 16) as these two parks have the greatest dissimilarities of spatial patterns between weekdays and weekends ($r = 0.105$ and 0.454 with $p < 0.001$ in Table 13) (Figure 16). In Bourbonnière, the hotspot of weekday activity is found on the tennis courts, while a slightly larger density of users can be found around the baseball fields during the weekend. This demonstrates that in suburban parks, like in Bourbonnière, the sports fields seem to be used primarily on weekends and corroborates the spatial analysis results.

In Chamberland, the density of users is higher during weekdays near the playground and on the basketball court, the density is higher during the weekend in the swimming pool, but the difference between weekday and weekend does not vary much. Otherwise, the correlations confirm the consistent whole-week usage in the other urban core parks, Hochelaga and

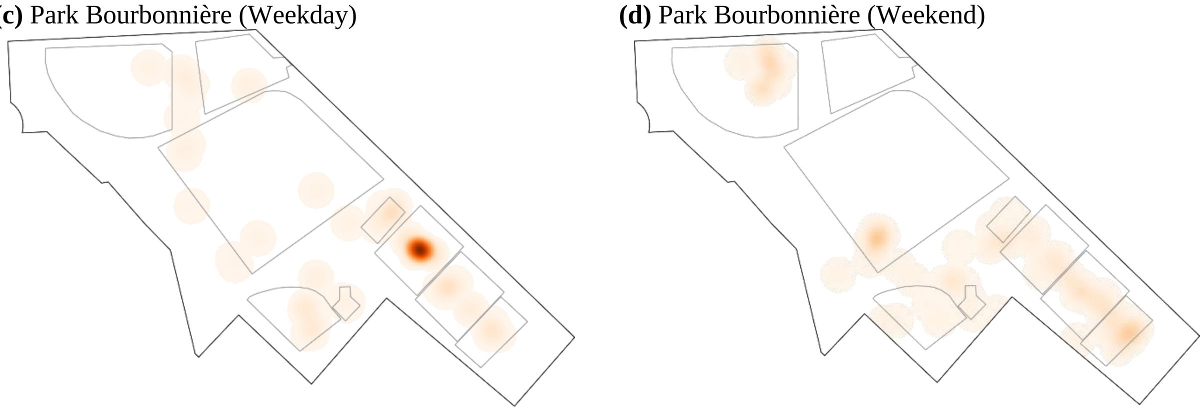
Wilson, that we observe in the percentages of usage in Table 14 (their correlation coefficients being $r = 0.847$ and 0.723 with $p < 0.001$, respectively in Table 13).

(a) Park Bariteau (Weekday) **(b)** Park Bariteau (Weekend)



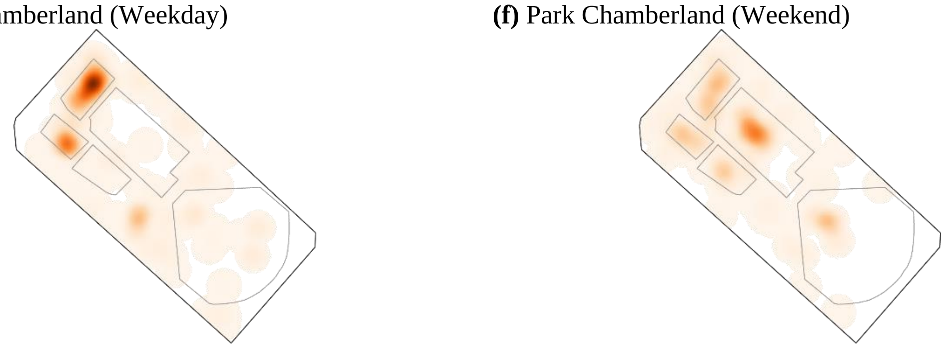
Note: Pearson's correlation between the two kernel density estimations: 0.751.

(c) Park Bourbonnière (Weekday) **(d)** Park Bourbonnière (Weekend)



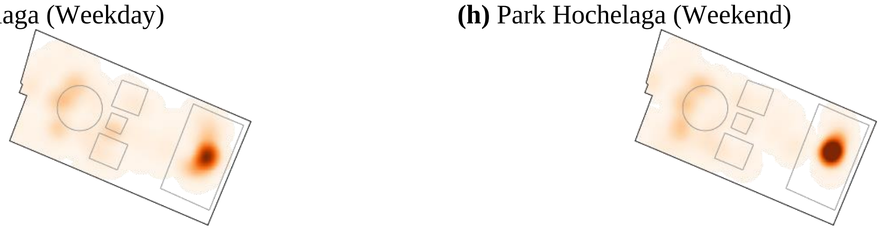
Note: Pearson's correlation between the two kernel density estimations: 0.105.

(e) Park Chamberland (Weekday) **(f)** Park Chamberland (Weekend)



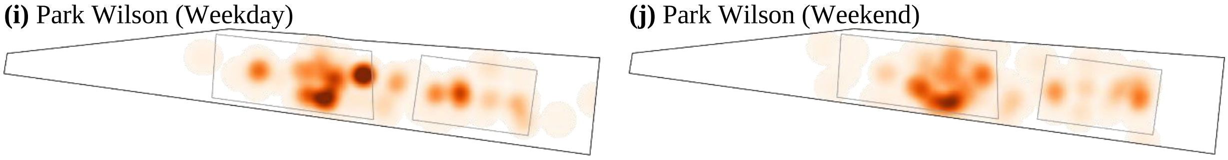
Note: Pearson's correlation between the two kernel density estimations: 0.454.

(g) Park Hochelaga (Weekday) **(h)** Park Hochelaga (Weekend)



Note: Pearson's correlation between the two kernel density estimations: 0.847.

(i) Park Wilson (Weekday) **(j)** Park Wilson (Weekend)



Note: Pearson's correlation between the two kernel density estimations: 0.723.

Figure 16. Density mapping for weekday and weekend visits.

Concerning the time period, we find three main significant associations: the lowest percentage of afternoon visitors (35.4%) for Parc Wilson and the lowest and highest percentages of evening visitors for Parc Chamberland (21.0%) and Parc Bucarest (52.1%) (Table 15). Surprisingly, Wilson is consistently occupied across the three time periods all while also experiencing the lowest percentage of afternoon visitors. This can be explained by the presence of families earlier in the morning and after the lunch hour in Wilson, leaving the park emptier in the afternoon compared to the other parks. While Bucarest has very few visitors throughout the day, denoting a very typical suburban park, which people visit after work. Bariteau's location close to a daycare explains the increase of evening users after the daycare closes.

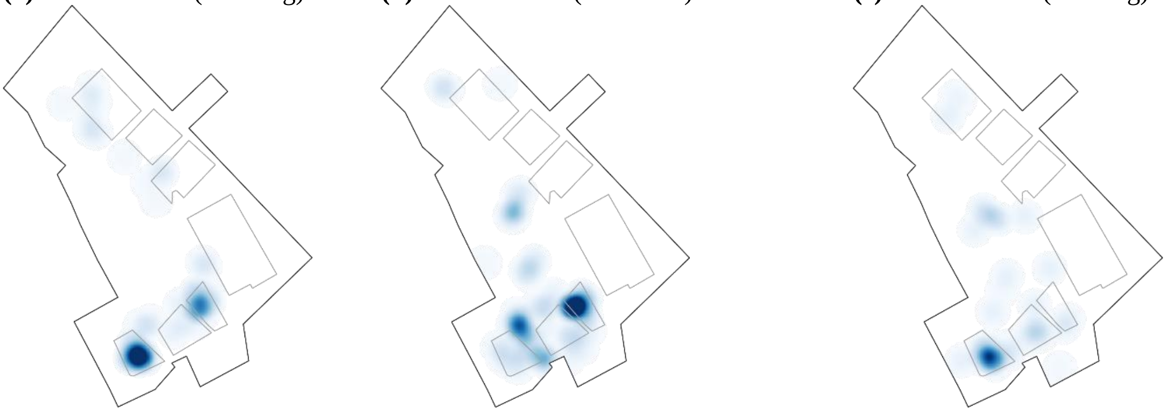
Table 15. Contingency table between time of day and parks.

	Frequencies per park						Percentages per park						
	Suburban			Urban Core			Suburban			Urban Core			
Time Period	BO	BU	BA	CH	WI	HO	BO	BU	BA	CH	WI	HO	All
Morning[a]	38	6	36	132	114	102	26.0	12.5	26.3	30.4	30.3	23.8	27.0
Afternoon[b]	65	17	68	211	133	191	44.5	35.4	49.6	48.6	35.4	42.7	43.1
Evening[c]	43	25	33	91	129	154	29.5	52.1	24.1	21.0	34.3	34.5	29.9

[a.] Morning: 9h to 12h. [b.] Afternoon: 12h-15h. [c.] Evening: 15h to 18h. BA: parc Bariteau; BO: parc Bourbonnière; BU: parc de Bucarest; CH: parc Chamberland; HO: parc Hochelaga; WI : parc Wilson.

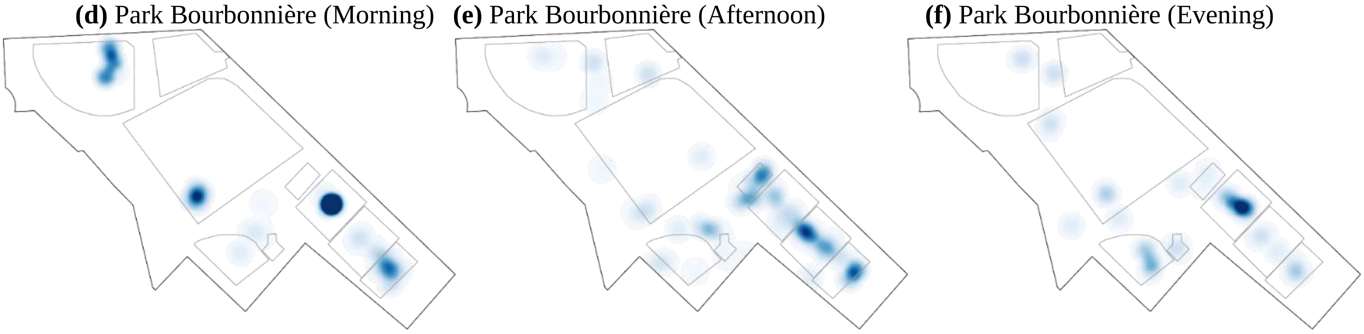
For the density correlations by time of day, the weaker correlation values are observed for the suburban Bourbonnière park (Table 13). Inversely, spatial patterns of the three time periods are very similar for the Hochelaga, Bariteau, and Wilson parks (Table 15 and Figure 17), suggesting that these three parks were used in a consistent way (spatially speaking) throughout the day. This could be explained by Hochelaga (j, k, and l in Figure 17) and Wilson being located in dense neighborhoods where individuals go to parks often because they have (m, n, and o in Figure 17) less private space, and perhaps could also be explained by the social fabrics in these neighborhoods being tighter (with people socializing more often and visiting the park with their kids). Bariteau's density of users by time period shows heavy use in the afternoon. The concentrated use of certain facilities, such as the playgrounds, can be explained by its proximity to the daycare and adults picking up their children after work (a, b, and c in Figure 17).

(a) Park Bariteau (Morning) **(b)** Park Bariteau (afternoon) **(c)** Park Bariteau (Evening)



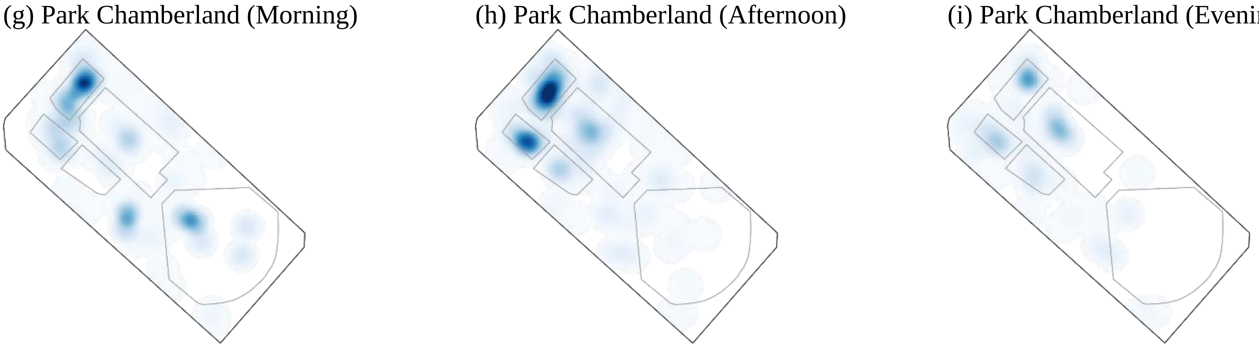
Note: Pearson's correlation between the A and B, B and C, C and A kernel density estimations: 0.477, 0.135, and 0.710.

(d) Park Bourbonnière (Morning) **(e)** Park Bourbonnière (Afternoon) **(f)** Park Bourbonnière (Evening)



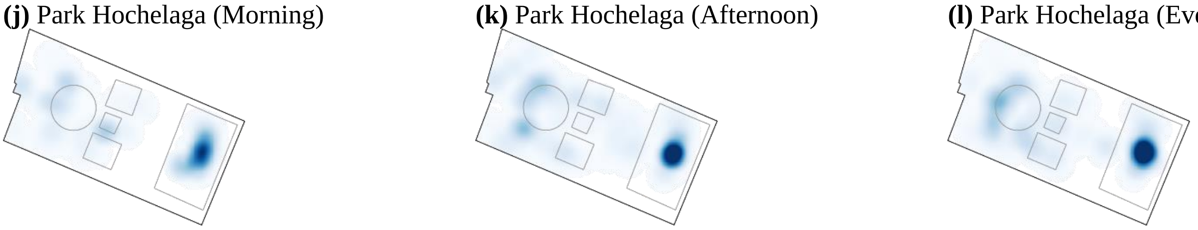
Note: Pearson's correlation between the D and E, E and F, F and D kernel density estimations: 0.098, 0.135, and 0.710.

(g) Park Chamberland (Morning) (h) Park Chamberland (Afternoon) (i) Park Chamberland (Evening)



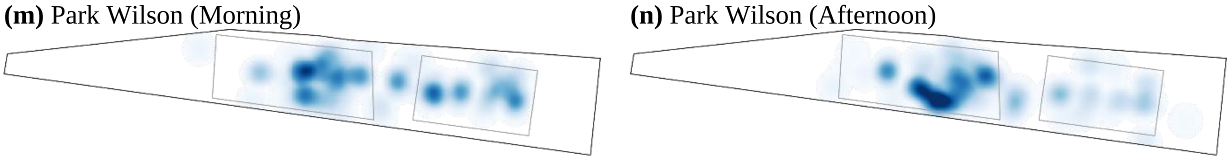
Note: Pearson's correlation between the G and H, H and I, I and G kernel density estimations: 0.640, 0.691, 0.517.

(j) Park Hochelaga (Morning) **(k)** Park Hochelaga (Afternoon) **(l)** Park Hochelaga (Evening)

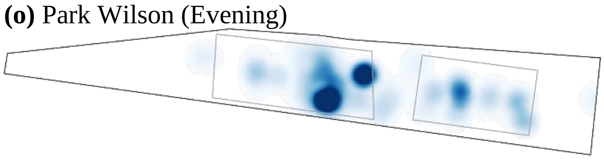


Note: Pearson's correlation between the J and K, K and L, L and J kernel density estimations: 0.864, 0.949, 0.878.

(m) Park Wilson (Morning) **(n)** Park Wilson (Afternoon)



(o) Park Wilson (Evening)



Note: Pearson's correlation between the M and N, N and O, O and M kernel density estimations: 0.530, 0.700, 0.699.

Figure 17. Density of users by the time period in each park.

These temporal patterns within these parks demonstrate the differences of usages between suburban and urban core parks. The tendency is that suburban parks, like Bourbonnière and Bariteau, have specific uses, such as the playground (Bariteau) and the sports fields, mainly tennis courts (Bourbonnière). In the three urban core parks (Chamberland, Hochelaga, and Wilson), the whole park surface was used in an even way, and this was consistent across all periods of observation.

4.4 Park Use According to Age Group and Group Size

The chi-square test of independence reveals there are significant associations between the six parks and age groups ($\chi2(5, N = 1588) = 37.6$, $p < 0.001$), as well as group size ($\chi2(20, N = 2032) = 198.8$), $p < 0.001$).

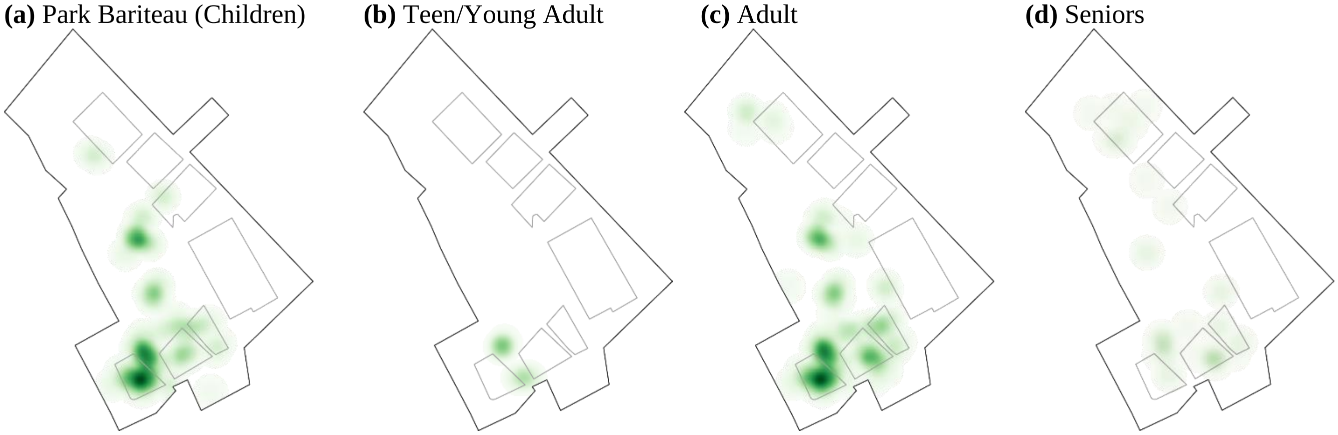
Table 16. Contingency table between age group and parks.

	Frequencies per park						Percentages per park						
	Suburban			Urban Core			Suburban			Urban Core			
Age	BO	BU	BA	CH	WI	HO	BO	BU	BA	CH	WI	HO	All
Children[a]	37	21	66	178	210	106	25.3	43.8	48.2	41.0	55.9	23.7	30.4
Teens and young adults[b]	30	8	5	51	32	31	20.5	16.7	3.7	11.8	8.5	6.9	7.7
Adults[c]	96	22	81	203	212	351	65.8	45.8	59.1	46.8	56.4	78.5	47.5
Seniors[d]	1	6	27	18	42	25	0.7	12.5	19.7	4.1	11.2	5.6	5.9
Not Collected	19	2	18	67	42	25	13.0	4.2	13.1	15.4	11.2	5.6	8.5

[a.]0-14 years old. [b.]15-24 years old. [c.]25-64 years old. [d.]65 and plus years old. BA: parc Bariteau; BO: parc Bourbonnière; BU: parc de Bucarest; CH: parc Chamberland; HO: parc Hochelaga; WI : parc Wilson.

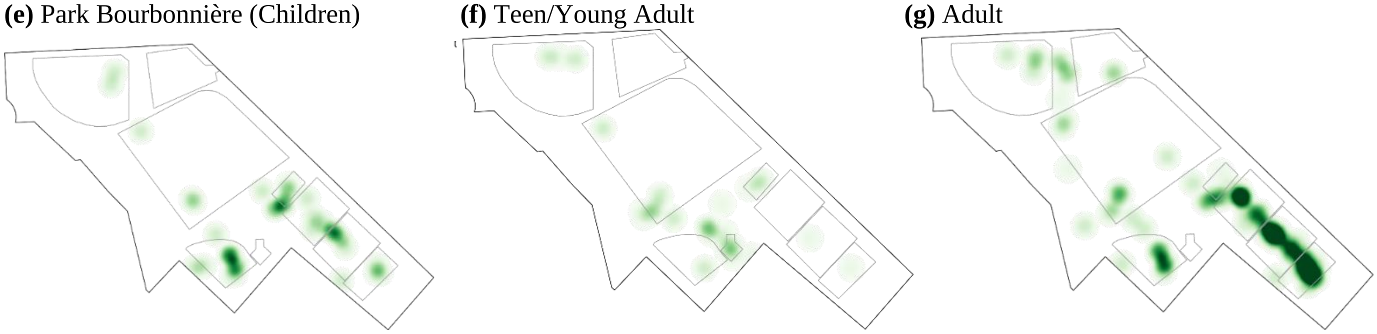
Concerning the demographic variable, teens and young adults, as well as seniors, were the least observed group for all parks (7.7% and 5.9%, Table 16), while children (0-14 years old) and adults (25-64 years old) are largest age groups of users (30.4% and 47.5%). Across the six parks, the variations of age groups do not seem to be associated with the fact that they are located in the suburban or in the urban core areas. For example, in the suburban parks, we observed the lowest but also the highest percentages of seniors (0.7% in Bourbonnière and 19.7% in Bariteau).

(a) Park Bariteau (Children) **(b)** Teen/Young Adult **(c)** Adult **(d)** Seniors

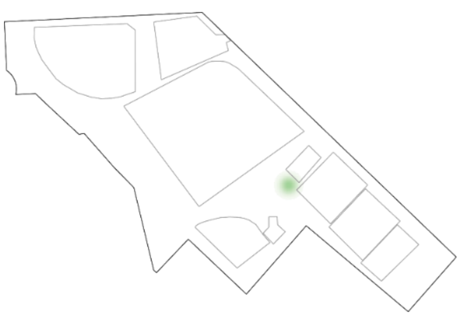


Note: Pearson's correlation between A and B, A and C, A and D, B and C, B and D, and C and D: 0.365, 0.915, 0.329, 0.352, 0.412, 0.489.

(e) Park Bourbonnière (Children) **(f)** Teen/Young Adult **(g)** Adult

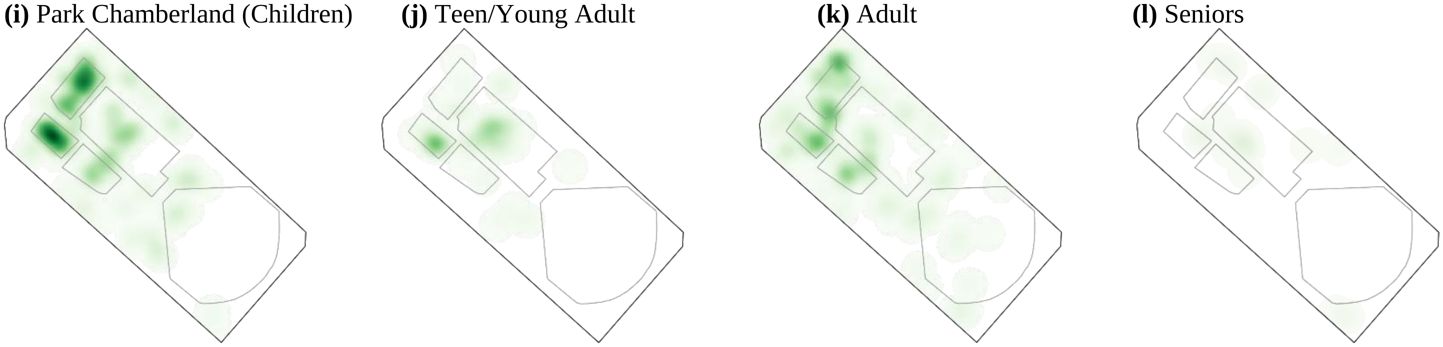


(h) Seniors



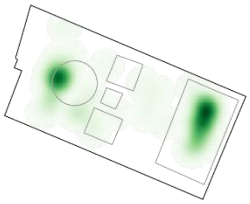
Note: Pearson's correlation between E and F, E and G, E and H, F and G, F and H, and G and H: 0.057, 0.558, 0.303, -0.012, -0.045, 0.077.

(i) Park Chamberland (Children) **(j)** Teen/Young Adult **(k)** Adult **(l)** Seniors

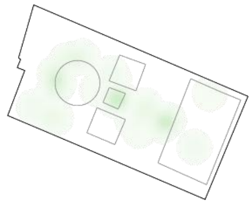


Note: Pearson's correlation between I and J, I and J, I and J, J and K, J and L, and K and L: 0.536, 0.770, 0.241, 0.402, 0.498, 0.347.

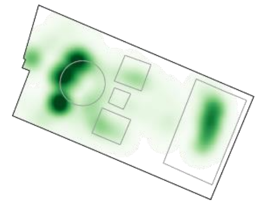
(m) Park Hochelaga (Children)



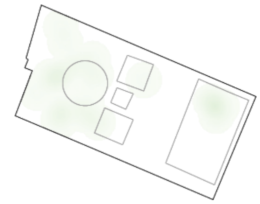
(n) Teen/Young Adult



(o) Adult

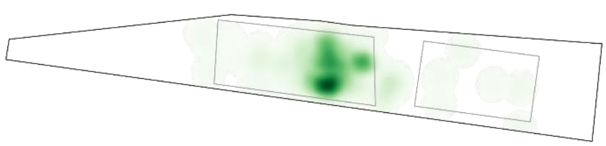


(p) Seniors

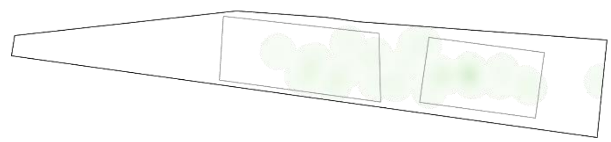


Note: Pearson's correlation between M and N, M and O, M and P, N and O, N and P, and O and P: 0.186, 0.736, 0.586, 0.338, 0.140, 0.592.

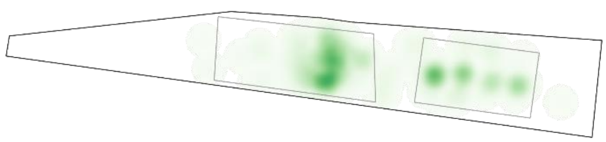
(m) Park Wilson (Children)



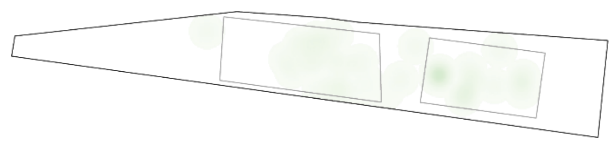
(n) Park Wilson (Teen/Young Adult)



(o) Park Wilson (Adult)



(p) Park Wilson (Seniors)



Note: Pearson's correlation between Q and R, Q and S, Q and T, R and S, R and T, and S and T: 0.272, 0.773, 0.274, 0.629, 0.520, 0.629.

Figure 18. Density of users by age group in each park.

Parc Bourbonnière has the largest dissimilarity when it comes to the kernel density correlations of age groups (weakest correlations in Table 13 and e, f, and g in Figure 18). Children and their parents (adults) tend to be in the playground areas, while teens and young adults are near the sports fields. Again, this spatial clustering of users suggests the spatial separation of users due to the type of equipment found in the park that people choose to use according to their age. Inversely, spatial patterns of the four age groups are very similar for the Hochelaga, Chamberland, Bariteau, and Wilson parks (with a slightly higher concentration of children and their parents in the playground). The spatial patterns highlight again the lack of teens or young adults and senior visitors.

Table 17. Contingence table between group size and parks.

	Frequencies per park						Percentages per park						
Group Size	BO	BU	BA	CH	WI	HO	BO	BU	BA	CH	WI	HO	**All**
One person	32	18	33	134	35	209	21.9	37.5	24.1	30.9	9.3	46.8	**29.0**
2-3 people	75	24	75	166	250	189	51.4	50.0	54.7	38.2	66.5	42.3	**49.1**
4-5 people	20	5	11	67	49	24	13.7	10.4	8.0	15.4	13.0	5.4	**11.1**
6-10 people	9	1	11	32	30	7	10.0	2.1	8.0	7.4	8.0	1.6	**5.7**
11-20 people	10	6	7	19	10	8	18.5	0.0	5.1	4.4	2.7	1.8	**3.4**
More than 20	0	0	0	16	2	10	0.0	0.0	0.0	3.7	0.5	2.2	**1.8**

BA: parc Bariteau; BO: parc Bourbonnière; BU: parc de Bucarest; CH: parc Chamberland; HO: parc Hochelaga; WI : parc Wilson.

Concerning the group size, individual visitors and groups of 2-3 people were the most observed (29% and 49.1%) (Table 17). Larger groups with 6-10 people, 11-20 people, or more than 20, were much less observed in all parks (5.7%, 2.4%, and 1.8%, respectively). Some differences between the parks are worth mentioning. Larger groups were found in Chamberland (15.4% for 4-5 people and 3.7% for more than 20 people) due to summer camps and on the tennis courts in Bourbonnière (18.5% for 11-20 people). In Parc Hochelaga, individuals and smaller groups were omnipresent (46.8% and 42.3%), which may be due to the lack of sports fields. Groups of 2 or 3 are quite important in Parc Wilson (66.5%), often due to tennis court pairs or small families visiting the playground. The spatial maps (Figure 19) show more significant numbers of people in Chamberland, Hochelaga, and Wilson compared to Bariteau and Bourbonnière. The maps of individuals and groups in Figure 19 show that park use in various sizes is concentrated around the playgrounds in Bariteau and the sports facilities in Bourbonnière and Chamberland. The individual visitors can be seen in Parc Hochelaga in the area where picnic tables and benches are found, while a concentration of larger groups on the playground is present. Lastly, the mix of both groups of 2 or 3 and larger groups are found throughout Parc Wilson.

In sum, variations in age and group size across and within the parks are influenced by facilities in the parks (sports, specifically) and the needs of a specific group located near the parks (schools and daycares, specifically).

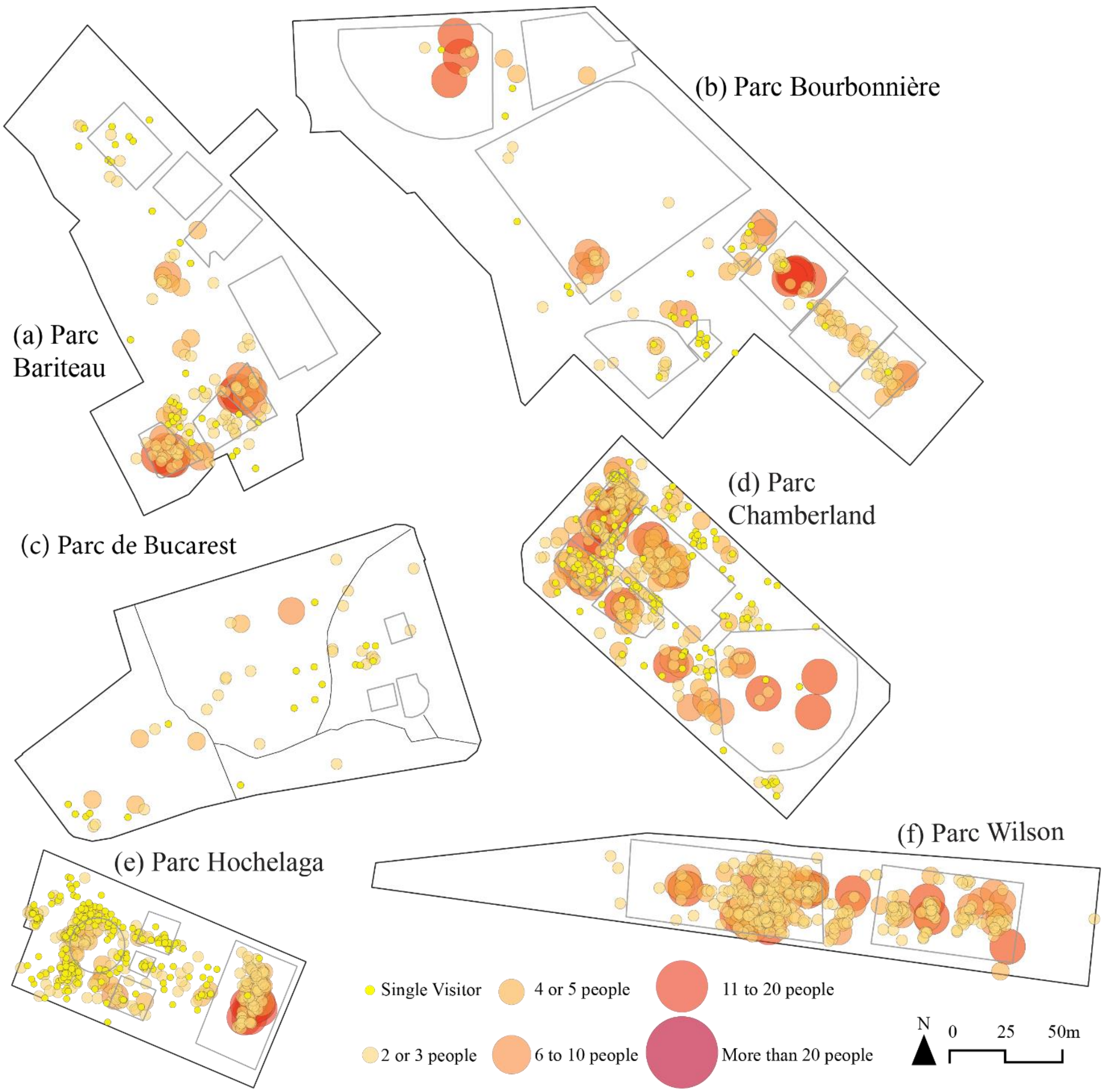


Figure 19. Park use by group size in each park.

4.5 Conclusion

These findings highlight the importance of fine-grained observation data to analyze park usage patterns, crowding, and park configurations. Bivariate and visual analyses point to some determinants of park crowding, i.e., accessibility indicators (proximity and hectares per person), urban services near the parks (e.g., daycares), and park equipment. Facilities attract all visitors, but a low presence of adolescents and seniors is observed in all parks. Furthermore, urban core parks offer less passive activity infrastructure but have more diverse uses and crowding than suburban parks. These results provide a more in-depth analysis of the differences between parks and will be further evaluated when analyzing park users' perceptions in Chapter 5.

CHAPTER 5: AN EXPLORATION OF MICRO-DATA ON PARK FREQUENCY, DURATION, AND CROWDING AS INSIGHT INTO PARK PERCEPTION

5.1 Introduction

Two types of analysis are conducted to respond to the third objective: *How do visitors' behavior influence the frequency of visits, duration, and perception of crowding in Greater Montreal parks?* The first type is a bivariate analysis involving contingency tables and chi-squared tests of independence presented in Section 5.2. The dependent variables tested are park visit frequency, duration, self-perceived crowding, and perceived crowding by others. The independent variables tested are transport mode, gender, visible minority member identification, income, park type, day, time, and reason for the visit. In the following results, only the significant associations (at $p<0.05$ threshold) are reported. The second analysis, through ordinal regressions, shows the various probabilities of park visits, as presented in Section 5.3. Finally, the conclusion in Section 5.4. summarizes the different influences on park use and highlights the various factors that affect users' perception of parks.

Lastly, for this third objective, we are now referring to the more subjective experience of crowding, and not potential congestion, as we are using park perception as a proxy for understanding the experience of crowding, drawing inspiration from the concept of functional density.

5.2 Bivariate analyses: Variables significantly associated with park visit frequency, duration, and park crowding

5.2.1 The influence on park visit frequency

When considering all the six parks, the most popular answer for *visit frequency* is often (i.e., daily or few times a week) (96 responses, 64%), followed by sometimes (i.e., once a week or few times a month) (43 responses, 28.7%), and rarely (i.e., few times a year or the first time visiting (11 responses, 7.3%) (Table 18). This indicates that people frequently visit their neighborhood parks.

The only significant chi-square test of independence for park visit frequency is the *reason for the visit*, $\chi^2(12, N = 150) = 22.5$, p= 0.0322 (Table 18). A large number of respondents visit the park for the playground (73 responses, 48.7%), then for sport (25 responses, 16.7%), and for picnics (19 responses, 12.7%). Most respondents who go to the park frequently visit the playground (53 responses, 72.6%); this is by far the largest response. The second most popular answers are tied with 17 responses: respondents who visit often for sport and those who sometimes visit for the playground. Frequent visitors are underrepresented when picnicking (5 responses, 5.2%) and visitors who sometimes visit for picnicking are overrepresented (12 responses, 63.2%). The responses show that people visit their park often or sometimes, and more particularly, more often for the playground.

Table 18. Crosstabulation between visit frequency and reason for visit.

Count Expected Values Chi-square contribution Row Percent Column Percent Std Residual	**Reason for Visit**							
Frequency	**Bike**	**Playground**	**Nature**	**Picnic**	**Solitude**	**Sport**	**Walk**	**Row Total**
Often	0	53	7	5	7	17	7	96
	0.64	46.72	8.32	12.16	6.40	16.0	5.76	
	0.64	0.84	0.21	4.22	0.06	0.06	0.27	
	0.00%	55.21%	7.29%	5.21%	7.29%	17.71%	7.29%	64.00%
	0.00%	72.60%	53.85%	26.32%	70.00%	68.00%	77.78%	
	-0.80	0.92	-0.46	-2.05	0.24	0.25	0.52	
Sometimes	1	17	4	12	3	5	1	43
	0.29	20.93	3.73	5.45	2.87	7.17	2.58	
	1.78	0.74	0.02	7.88	0.01	0.66	0.97	
	2.33%	39.53%	9.30%	27.91%	6.98%	11.63%	2.33%	28.67%
	100.00%	23.29%	30.77%	63.16%	30.00%	20.00%	11.11%	
	1.33	-0.86	0.14	2.81	0.08	-0.81	-0.98	
Rarely	0	3	2	2	0	3	1	11
	0.07	5.35	0.95	1.39	0.73	1.83	0.66	
	0.07	1.03	1.15	0.26	0.73	0.74	0.18	
	0.00%	27.27%	18.18%	18.18%	0.00%	27.27%	9.09%	7.33%
	0.00%	4.11%	15.38%	10.53%	0.00%	12.00%	11.11%	
	-0.27	-1.02	1.07	0.51	-0.86	0.86	0.42	
Column Total	1	73	13	19	10	25	9	150[a]
	0.67%	48.67%	8.67%	12.67%	6.67%	16.67%	6.00%	

Pearson's Chi-squared test

Chi^2=22.51, d.f.=12, p=0.0322. Cells with Expected Frequency < 5: 11 of 21 (52.38%).

[a.] Due to missing values, one observation is omitted from the analysis.

5.2.2 The influence on park visit duration

The significant chi-square tests of independence are between the visit duration and 1) transport mode, 2) income, 3) time of visit, and 4) reason. Before exploring these associations, it should be noted that the most recorded visit length is split between more than an hour (56 responses, 38.1%), 30 to 60 minutes (55 responses, 37.4%), and less than 30 minutes (36 responses, 25.2%). This indicates that visitors spend a considerable amount of time in the parks.

First, the relation between the *mode of transport* and *visit duration* is significant, $\chi^2(4, N = 147) = 17.66, p=0.0014$ (Table 19). In terms of transport, the most popular responses are by foot (89 responses, 60.5%), by car (43 responses, 29.3%), and by bike (15 responses, 10.2%). This demonstrates that a significant number of park visitors travel on foot. Furthermore, there is an underrepresentation of visitors by car who visit for less than 30 minutes (3 responses, 7.0%). This means most people traveling by car visit for 30 to 60 minutes (22 responses, 51.2%) or more than 60 minutes (18 responses, 41.9%). Those who visit by foot tend to visit no matter the duration, as the responses are quite similar (30, 31, and 28 responses, respectively, for less than 30 minutes, 30 to 60 minutes, and more than an hour). Visitors by bike are more likely to respond that their visit is more than an hour (10 responses, 66.7%) compared to smaller durations (3 responses for less than 30 minutes, 20%, and 2 responses for 30 to 60 minutes, 13.3.%). The difference between walkers and those by car could be explained by the types of activities in the park, the distance to the park, or the ease of traveling by foot in the neighborhood.

Table 19. Crosstabulation between visit duration and mode of transport.

Count Expected Values Chi-square contribution Row Percent Column Percent Std Residual	Mode of Transport			
Duration	**Foot**	**Bike**	**Car**	**Row Total**
Less than 30 minutes	30	3	3	36
	21.80	3.67	10.53	
	3.09	0.12	5.39	
	83.33%	8.33%	8.33%	25.17%
	33.71%	20.00%	6.98%	
	1.76	-0.35	-2.32	
30 to 60 minutes	31	2	22	55
	33.30	5.61	16.09	
	0.16	2.32	2.17	
	56.36%	3.64%	40.00%	37.41%
	34.83%	13.33%	51.16%	
	-0.40	-1.52	1.47	
More than one hour	28	10	18	56
	33.90	5.71	16.38	
	1.03	3.21	0.16	
	50.00%	17.86%	32.14%	38.10%
	31.46%	66.67%	41.86%	
	-1.01	1.79	0.40	
Column Total	89	15	43	147[a]
	60.54%	10.20%	29.25%	

Pearson's Chi-squared test
Chi^2=17.66, d.f.=4, p=0.0014. Cells with Expected Frequency < 5: 1 of 9 (11.11%).
[a.] Due to missing values, four observations are omitted from the analysis.

Second, the relation between visit duration and income is significant, $\chi 2(10, N = 148) = 21.44$, $p=0.0204$ (Table 20). The responses for income with the four most responses are *prefer not to answer* with 35 responses, $70,000 to $99,999 with 32 responses, $50,000 to $69,999 with 24 responses, and more than $100,000 with 20 responses. The most popular response is *prefer not to answer* and a visit duration of more than one hour (17 responses). However, when looking at reported income levels, there is an equal number of respondents earning $50,000 to $69,999 and $70,000 to $99,999 visiting for 30 to 60 minutes (13 responses, 23.2% for both). The highest response for less than 30 minutes is from individuals earning $70,000 to $99999 (12 responses, 33.3%), and for visits of more than one hour, individuals earning more than $100,000 (12 responses, 21.4%). There is an over-representation of those earning $30,000 to $49,999 who visit for less than 30 minutes (8 responses, 50.0%). Among those who earned the most, 60% stayed more than one hour. Other groups stayed less in the parks, but those who earned the least spent more time than the other groups. This suggests a nonlinear relationship between income and visit duration.

Table 20. Crosstabulation between visit duration and income.

Count Expected Values Chi-square contri. Row Percent Column Percent Std Residual	Reason for Visit						
Duration	<$29999	$30000-49999	$50000-69999	$70000-$99999	>$100000	Prefer not to answer	**Row Total**
Less than 30 minutes	3	8	5	12	2	6	36
	5.11	3.89	5.84	7.78	4.86	8.51	
	0.87	4.34	0.12	2.28	1.69	0.74	
	8.33%	22.22%	13.89%	33.33%	5.56%	16.67%	24.32%
	14.29%	50.00%	20.83%	37.50%	10.00%	17.14%	
	-0.93	2.08	-0.35	1.51	-1.30	-0.86	
30 to 60 minutes	9	3	13	13	6	12	56
	7.95	6.05	9.08	12.11	7.57	13.24	
	0.14	1.54	1.69	0.07	0.32	0.12	
	16.07%	5.36%	23.21%	23.21%	10.71%	21.43%	37.84%
	42.86%	18.75%	54.17%	40.62%	30.00%	34.29%	
	0.37	-1.24	1.30	0.26	-0.57	-0.34	
More than one hour	9	5	6	7	12	17	56
	7.95	6.05	9.08	12.11	7.57	13.24	
	0.14	0.18	1.05	2.15	2.60	1.07	
	16.07%	8.93%	10.71%	12.50%	21.43%	30.36%	37.84%
	42.86%	31.25%	25.00%	21.88%	60.00%	48.57%	
	0.37	-0.43	-1.02	-1.47	1.61	1.03	
Column Total	21	16	24	32	20	35	148[a]
	14.19%	10.81%	16.22%	21.62%	13.51%	23.65%	

Pearson's Chi-squared test
Chi^2=21.1, d.f.=10, p=0.0204. Cells with Expected Frequency < 5: 2 of 18 (11.1%).
[a.] Due to missing values, three observations are omitted from the analysis.

Third, the chi-square test of independence reveals a significant association between duration and time of park visit, $\chi^2(4, N = 151) = 14.27$, p=0.0065 (Table 21).

When reviewing the responses, morning visitors are the least surveyed (this alludes to fewer people parks in the morning) (14 responses, 9.3%). In comparison, afternoon and evening survey responses are much larger (56 responses, 37.1%, and 81 responses, 53.6%, respectively). For morning visitors, the visit lasts more than one hour (11 responses, 78.6%). Afternoon and evening visits are the more popular and evenly spread across duration categories. Responses for afternoon visits are highest for 30 to 60 minutes park visits (25 responses, 43.6%), followed by less than 30 minutes (17 responses, 30.4%), and more than one hour (14 responses, 25.0%). Responses for evening visits were even between 30 to 60 minutes and more than one hour (31 responses, 38.3% for both), and 19 responses for visits less than 30 minutes in the evening (23.5%). This indicates more time spent in parks in the afternoon and evening, with particularly long visits in the evening.

Visits lasting more than one hour are underrepresented in the morning (11 responses, 19.34%), however, those who visited in the morning tended to stay longer. Totals are similar between afternoon and evening visits lasting less than 30 minutes (17 and 19 responses, respectively) and 30 to 60 minutes (25 and 31 responses, respectively). However, visits lasting less than 60 minutes were slightly overrepresented in the evening compared to the afternoon (50% for less than 30 minutes and 54.39% for 30 to 60 minutes).

Table 21. Crosstabulation between visit duration and time of visit.

Count Expected Values Chi-square contribution Row Percent Column Percent Std Residual	Time of Visit			
Duration	Morning	Afternoon	Evening	**Row Total**
Less than 30 minutes	2	17	19	38
	3.52	14.09	20.38	
	0.66	0.60	0.09	
	5.26%	44.74%	50.00%	25.17%
	14.29%	30.36%	23.46%	
	-0.81	0.77	-0.31	
30 to 60 minutes	1	25	31	57
	5.28	21.14	30.58	
	3.47	0.71	0.01	
	1.75%	43.86%	54.39%	37.75%
	7.14%	44.64%	38.27%	
	-1.86	0.84	0.08	
More than one hour	11	14	31	56
	5.19	20.77	30.04	
	6.50	2.21	0.03	
	19.64%	25.00%	55.36%	37.09%
	78.57%	25.00%	38.27%	
	2.55	-1.49	0.18	
Column Total	14	56	81	151
	9.27%	37.09%	53.64%	

Pearson's Chi-squared test
Chi^2=14.27, d.f.=4, p=0.0065. Cells with Expected Frequency < 5: 1 of 9 (11.11%).

Lastly, the relation between the reason for visit and visit duration is also significant, (χ^2(12, N = 150) = 32.82, p=0.0010) (Table 22). The most popular response for any park visit duration is for the playground (15 responses for less than 30 minutes, 33 responses for 30 to 60 minutes, and 25 responses for more than one hour). The only other categories with several responses are those visiting the park for sports for more than one hour (17 responses) and those visiting to picnic for more than one hour (10 responses). All other categories have less than 10 responses. This indicates the playground is the activity in which people spend the most time.

Responses for park visits less than 30 minutes are overrepresented for those walking (6 responses, 66.7%), while visits for more than one hour are overrepresented for sport (17 responses, 68.0%). Those walking tend to spend less time in the park, and those visiting the playground, playing sports, or picnicking tend to spend more time there.

Table 22. Crosstabulation between visit duration and reason for visit.

Count Expected Values Chi-square contribution Row Percent Column Percent Std Residual	Reason for Visit							
Duration	**Bike**	**Playground**	**Nature**	**Picnic**	**Solitude**	**Sport**	**Walk**	**Row Total**
Less than 30 minutes	1	15	6	4	3	2	6	37
	0.25	18.01	3.21	4.69	2.47	6.17	2.22	
	2.30	0.50	2.43	0.10	0.12	2.82	6.44	
	2.70%	40.54%	16.22%	10.81%	8.11%	5.41%	16.22%	24.67%
	100.00%	20.55%	46.15%	21.05%	30.00%	8.00%	66.67%	
	1.52	-0.71	1.56	-0.32	0.34	-1.68	2.54	
30 to 60 minutes	0	33	6	5	5	6	2	57
	0.38	27.74	4.94	7.22	3.80	9.50	3.42	
	0.38	1.00	0.23	0.68	0.38	1.29	0.59	
	0.00%	57.89%	10.53%	8.77%	8.77%	10.53%	3.51%	38.00%
	0.00%	45.21%	46.15%	26.32%	50.00%	24.00%	22.22%	
	-0.62	1.00	0.48	-0.83	0.62	-1.14	-0.77	
More than one hour	0	25	1	10	2	17	1	56
	0.37	27.25	4.85	7.09	3.73	9.33	3.36	
	0.37	0.19	3.06	1.19	0.80	6.30	1.66	
	0.00%	44.64%	1.79%	17.86%	3.57%	30.36%	1.79%	37.33%
	0.00%	34.25%	7.69%	52.63%	20.00%	68.00%	11.11%	
	-0.61	-0.43	-1.75	1.09	-0.90	2.51	-1.29	
Column Total	1	73	13	19	10	25	9	150[a]
	0.67%	48.67%	8.67%	12.67%	6.67%	16.67%	6.00%	

Pearson's Chi-squared test
Chi^2=32.82, d.f.=12, p=0.0010. Cells with Expected Frequency < 5: 13 of 21 (61.9%).
[a.] Due to missing values, one observation is omitted from the analysis.

5.2.3 The influences on park crowding perception

For these analyses on park crowding, the significant chi-square tests of independence are between self-perceived park crowding and 1) transport mode, 2) visible minority group identification, and 3) park type.

For park crowding, the three most popular responses are sometimes (50 responses, 34.7%), rarely (38 responses, 26.4%), and never (38 responses, 26.4%). This indicates that there are varying opinions on park crowding with the category sometimes perceiving crowding having a narrow increase in responses.

The first chi-square test of independence for this category of variables reveals a significant association between the perception of crowding and transport, $\chi 2(6, N = 144) = 14.13$, $p = 0.0282$ (Table 23). The three most popular responses are visitors traveling by foot either thinking their park is sometimes crowded (34 responses), rarely crowded (24 responses), or never crowded (23 responses). Following this, the only other popular category is visitors traveling by car, thinking their park is sometimes crowded (15 responses).

Respondents traveling by bike who answered never to the crowding experiences are overrepresented (8 responses, 53.3%). There is no drastic difference between traveling by bike or by car and self-perception of crowding. However, visitors by foot are more likely to respond to sometimes experiencing crowding.

Table 23. Crosstabulation of self-perception of crowding and transport.

Count Expected Values Chi-square contribution Row Percent Column Percent Std Residual	Mode of Transport			
Self-Perception of Crowding	**Foot**	**Bike**	**Car**	**Row Total**
Often	8 11.12 0.88 44.44% 8.99% -0.94	1 1.88 0.41 5.56% 6.67% -0.64	9 5.00 3.20 50.00% 22.50% 1.79	18 12.50%
Sometimes	34 30.90 0.31 68.00% 38.20% 0.56	1 5.21 3.40 2.00% 6.67% -1.84	15 13.89 0.09 30.00% 37.50% 0.30	50 34.72%
Rarely	24 23.49 0.01 63.16% 26.97% 0.11	5 3.96 0.27 13.16% 33.33% 0.52	9 10.56 0.23 23.68% 22.50% -0.48	38 26.39%
Never	23 23.49 0.01 60.53% 25.84% -0.10	8 3.96 4.13 21.05% 53.33% 2.03	7 10.56 1.20 18.42% 17.50% -1.09	38 26.39%
Column Total	89 61.81%	15 10.42%	40 27.78%	144[a]

Pearson's Chi-squared test
Chi^2=14.13, d.f.=6, p=0.0282. Cells with Expected Frequency < 5: 3 of 12 (25%).
[a] Due to missing values, seven observations values are omitted from the analysis.

Second, the relation between the perception of crowding and identifying as a visible minority member indicates it is significant, $\chi^2(6, N = 148) = 14.61$, p=0.0235.

For visible minority identification, 29 participants self-identify as being members of a visible minority (19.6%), 101 respondents do not (68.2%), and 18 chose not to answer (12.2%) (Table 24). For those identifying as members of a visible minority, the highest response is sometimes perceiving the park as crowded (13 responses, 44.8%). For those who do not identify as members of a visible minority, there is a split between sometimes (32 responses, 31.7%), rarely

(32 responses, 31.7%), and never (30 responses, 29.7%). There are no big differences between responses for those who chose not to answer; the highest response was sometimes (8 responses, 44.4%). This indicates a larger, though minimal, perception of crowding by those identifying as members of a visible minority. Nonetheless, there is still the impression that park crowding is perceived.

Table 24. Crosstabulation between self-perception of crowding and visible minority member identification.

Count Expected Values Chi-square contribution Row Percent Column Percent Std Residual	**Visible Minority Identification**			
Self-Perception of Crowding	**Yes**	**No**	**No Answer**	**Row Total**
Often	7	7	4	18
	3.53	12.28	2.19	
	3.42	2.27	1.5	
	38.89%	38.89%	22.22%	12.16%
	24.14%	6.93%	22.22%	
	1.85	-1.51	1.22	
Sometimes	13	32	8	53
	10.39	36.17	6.45	
	0.66	0.48	0.37	
	24.53%	60.38%	15.09%	35.81%
	44.83%	31.68%	44.44%	
	0.81	-0.69	0.61	
Rarely	5	32	2	39
	7.64	26.61	4.74	
	0.91	1.09	1.59	
	12.82%	82.05%	5.13%	26.35%
	17.24%	31.68%	11.11%	
	-0.96	1.04	-1.26	
Never	4	30	4	38
	7.45	25.93	4.62	
	1.59	0.64	0.08	
	10.53%	78.95%	10.53%	25.68%
	13.79%	29.70%	22.22%	
	-1.26	0.8	-0.29	
Column Total	29	101	18	148[a]
	19.59%	68.24%	12.16%	

Pearson's Chi-squared test
Chi^2= 14.61, d.f.=6, p=0.0235. Cells with Expected Frequency < 5: 4 of 12 (33.33%).

[a.] Due to missing values, three observations are omitted from the analysis.

Third, there is a significant association between the self-perception of crowding and park type, $\chi^2(3, N = 148) = 41.87, p < 0.0001$ (Table 25). The most popular answer for those visiting suburban parks is never (19 responses, 76.0%). For those in urban core parks, there are also 19 responses (15.5%) for never perceiving crowding. However, the other categories are much more popular. In ascending order, the most popular crowding responses for urban core parks are often (15 responses, 12.2%), rarely (38, 30.9%), and sometimes (51 responses, 41.5%). This indicates a much higher self-perceived crowding in urban core parks.

Given the equal number of never responses for both park types, there is an overrepresentation of respondents in suburban parks who are more likely to find the park never crowded. On the other hand, those in urban parks are underrepresented in experiences of never finding the park crowded. Similarly, respondents in suburban parks are less likely to respond that their park is sometimes or rarely busy. This confirms that there are more experiences perceiving park crowding in urban core parks.

Table 25. Crosstabulation between self-perception of crowding and park type.

Count Expected Values Chi-square contribution Row Percent Column Percent Std Residual	**Park type**		
Self-Perception of Crowding	**Urban Core**	**Suburb**	**Row Total**
Often	15	3	18
	14.96	3.04	
	0	0	
	83.33%	16.67%	12.16%
	12.20%	12.00%	
	0.01	-0.02	
Sometimes	51	2	53
	44.05	8.95	
	1.1	5.4	
	96.23%	3.77%	35.81%
	41.46%	8.00%	
	1.05	-2.32	
Rarely	38	1	39
	32.41	6.59	
	0.96	4.74	
	97.44%	2.56%	26.35%
	30.89%	4.00%	
	0.98	-2.18	
Never	19	19	38
	31.58	6.42	
	5.01	24.66	
	50.00%	50.00%	25.68%
	15.45%	76.00%	
	-2.24	4.97	
Column Total	123	25	148[a]
	83.11%	16.89%	

Pearson's Chi-squared test
Chi^2=41.87, d.f.= 3, p=0.000. Cells with Expected Frequency < 5: 1 of 8 (12.5%).

[a] Due to missing values, three observations are omitted from the analysis.

5.2.4 The influence on park crowding perception by others

The only significant chi-square of independence test shows a significant association between crowding perception by others (predominately in social networks) and park type, $\chi^2(4, N = 147) = 9.139, p=0.0275$ (Table 26).

In this case, similar patterns are viewed between the perception of crowding by others and the park type. The largest response group for suburban parks is never (22 responses, 88.0%). For urban core parks, the most popular answer was also never (74 responses, 60.7%), followed by rarely (31 responses, 25.4%) and sometimes (14 responses, 11.5%). While there is an underrepresentation of suburban park visitors who responded that their social network found the park rarely crowded, there are many ‘never’ responses for urban core parks than in self-perceived crowding. Therefore, urban core respondents have people in their social networks who perceive park crowding more than suburban parks. However, many more respondents have people in their entourage who do not believe that their park is crowded. This indicates that it might not be a topic of discussion between friends and family or that visiting the park where familiar people are is not considered crowding.

Table 26. Crosstabulation between perception of crowding by others and park type.

Count Expected Values Chi-square contribution Row Percent Column Percent Std Residual	Park type		
Crowding Experienced by Others	**Urban Core**	**Suburb**	**Row Total**
Often	3	1	4
	3.32	0.68	
	0.03	0.15	
	75.00%	25.00%	2.72%
	2.46%	4.00%	
	-0.18	0.39	
Sometimes	14	2	16
	13.28	2.72	
	0.04	0.19	
	87.50%	12.50%	10.88%
	11.48%	8.00%	
	0.2	-0.44	
Rarely	31	0	31
	25.73	5.27	
	1.08	5.27	
	100.00%	0.00%	21.09%
	25.41%	0.00%	
	1.04	-2.3	
Never	74	22	96
	79.67	16.33	
	0.4	1.97	
	77.08%	22.92%	65.31%
	60.66%	88.00%	
	-0.64	1.4	
Column Total	122	25	147[a]
	82.99%	17.01%	

Pearson's Chi-squared test
Chi^2=9.139, d.f.=4, p=0.0275. Cells with Expected Frequency < 5: 3 of 8 (37.5%).

[a.] Due to missing values, four observations are omitted from the analysis.

5.3 Ordinal logistic regressions: What affects the probability of park visit frequency, duration, and perception of crowding?

Ordinal logistic regression analyses were conducted to investigate whether park type, time of visit, day of the week, and visit reason predict park visit frequency, duration, self-perceived crowding, and crowding perceived by others. The four ordinal regressions are reported below.

First, the predictors of park visit frequency did not account for a significant amount of variance in the outcome, likelihood ratio χ^2 (6) = 12.16, p=0.059 (Table 27). Overall, the model accounted for approximately 4% of the variance in the outcome, McFadden's pseudo-R^2 = 0.048.

The only predictor significantly associated with visit frequency is the reason for park visits (Table 27). The estimated odds ratio (OR = 3.45, 95% CI, 1.51–8.13, p=0.004) indicates that those who visit to go to the playground are 3.45 times more likely to frequent the park regularly compared to respondents who visit for passive activity, holding all other variables constant. This suggests that reason is crucial to improving park frequency and, therefore, park use.

Table 27. Ordinal logistic regression: Coefficients of the model (Dependent variable: Frequency[a]).

Variable	Coef.	SE[b]	T value	OR[c]	OR (95%)[d]		P value
Park Type							
Ref : Suburban park	–	–	–	–	–	–	–
Urban core park	0.403	0.465	0.867	1.497	0.590	3.706	0.386
Time							
Ref : Morning	–	–	–	–	–	–	–
Afternoon	-0.753	0.879	-0.856	0.471	0.063	2.303	0.392
Evening	-1.078	0.880	-1.225	0.340	0.045	1.660	0.221
Day							
Ref : Weekend	–	–	–	–	–	–	–
Weekday	0.329	0.410	0.802	1.389	0.624	3.135	0.422
Reason							
Ref : Passive	–	–	–	–	–	–	–
Playground	1.238	0.427	2.899	3.447	1.513	8.128	**0.004**
Active	0.796	0.519	1.532	2.216	0.811	6.281	0.126
Threshold (cut point)							
Ref : Rarely	–	–	–	–	–	–	–
Rarely/Occasionally	-2.267	1.155	-1.963				0.050
Occasionally/Regularly	-0.212	1.133	-0.187				0.852
Fit statistics							
Likelihood ratio test[e]	$\boldsymbol{x^2}$	12.16					
	p-value	0.0585					
AIC[f]	**255.35**						
McFadden R^2	**0.0484**						
Cox and Snell R^2	**0.0774**						
Nagelkerke R^2	**0.0954**						

[a.] The ordinal categories are: Rarely, occasionally, regularly. [b.] SE: standard error. [c.] OR: Odd ratio.
[d] 95% confidence limits. [e] Results of the likelihood ratio tests for comparing the full model and the null model. [f.] Akaike information criterion.

Second, the predictors of park visit duration account for a significant amount of variance in the outcome, likelihood ratio χ^2 (6) = 13.91, p=0.031 (Table 28). Overall, the model accounted for approximately 4% of the variance in the outcome, McFadden's pseudo-R^2 = 0.043.

The time of visit is significantly associated with park visit duration. For respondents in the afternoon (OR = 0.154, 95% CI, 0.030–0.606, p=0.012), longer visits are 85% lower (i.e., (1 - 0.154) x 100) than those in the morning, holding all other variables constant. This indicates that the time of visit provides insight into how long visitors use the park supports the cross tables above, which indicate that respondents in the morning stay longer. On the other hand, those who come in the afternoon or evening spend different amounts of time in the park.

Table 28. Ordinal logistic regression: Coefficients of model (Dependent variable: Duration[a])

Variable	Coef.	SE[b]	T value	OR[c]	OR (95%)[d]		P value
Park Type							
Ref: Suburban park	–	–	–	–	–	–	–
Urban core park	0.121	0.431	0.281	1.129	0.481	2.628	0.779
Time							
Ref: Morning	–	–	–	–	–	–	–
Afternoon	-1.870	0.744	-2.514	0.154	0.030	0.606	**0.012**
Evening	-1.278	0.764	-1.673	0.279	0.053	1.149	0.094
Day							
Ref: Weekend	–	–	–	–	–	–	–
Weekday	0.451	0.365	1.234	1.570	0.769	3.233	0.217
Reason							
Ref: Passive	–	–	–	–	–	–	–
Playground	0.399	0.374	1.066	1.490	0.717	3.121	0.286
Active	0.535	0.494	1.083	1.708	0.648	4.529	0.279
Threshold (cut point)							
Ref: <30min	–	–	–	–	–	–	–
<30min/30_60min	-1.909	1.005	-1.898				0.058
30_60min/>1hour	-0.183	1.001	-0.183				0.855
Fit statistics							
Likelihood ratio test[e]	***x^2***	13.91					
	p-value	0.0306					
AIC[f]	**329.10**						
McFadden R^2	**0.0426**						
Cox and Snell R^2	**0.0880**						
Nagelkerke R^2	**0.0994**						

[a.] The ordinal categories are: Less than 30 minutes, 30 to 60 minutes, and more than one hour.
[b.] SE: standard error. [c.] OR: Odd ratio. [d.] 95% confidence limits. [e.] Results of the likelihood ratio tests for comparing the full model and the null model. [f.] Akaike information criterion.

Third, the self-perceived park crowding predictors accounted for a significant amount of variance in the outcome, likelihood ratio χ^2 (6) = 15.06, p=0.02 (Table 29). Overall, the model accounted for approximately 5% of the variance in self-perceived crowding, as indicated by McFadden's pseudo-R^2 = 0.047.

Both time of visit and reason are significantly associated with self-perceived park crowding. Compared to the morning, the odds of being more likely to rarely perceive crowding (as opposed to never or regularly) is 78% lower (i.e., (1 - 0.219) x 100) for respondents in the afternoon (OR = 0.219, 95% CI, 0.056–0.760, p=0.021), holding all other variables constant. Similarly, the odds of respondents in the evening (OR = 0.205, 95% CI, 0.051–0.737, p=0.019) being more likely to rarely perceive crowding are 80% (i.e., (1 - 0.205) x 100) lower than those in the morning, holding all other variables constant.

Visiting in the afternoon or evening reduces the probability of rarely perceiving park crowding. This highlights the importance of time in understanding the perception of crowdedness. In the analysis of influences on park crowding perception, time of visit is not found significant, however, it slightly accounts for variations in perceived crowding.

Moreover, the estimated odds ratio for self-perceived crowding indicates that respondents who visited to go to the playground (OR = 2.436, 95% CI, 1.153–5.205, p=0.020) were 2.44 times more likely to perceive crowding than respondents who visited for passive activity holding all other variables constant, highlighting the importance of activity in understanding crowding perception. The bivariate analyses failed to reveal any significant reason for park crowding. Visiting the playground is the most popular reason for visits in this study and users tend to find the park more crowded. This may also be indicative of a high functional density that adds more nuance to the analysis of park crowding and highlights the importance of understanding visitors' preferences and perceptions.

Table 29. Ordinal logistic regression: Coefficients of model (Dependent variable: Crowding[a])

Variable	Coef.	SE[b]	T value	OR[c]	OR (95%)[d]		P value
Park Type							
Ref: Suburban park	–	–	–	–	–	–	–
Urban core park	-0.025	0.403	-0.063	0.975	0.438	2.137	0.950
Time							
Ref: Morning	–	–	–	–	–	–	–
Afternoon	-1.521	0.659	-2.310	0.219	0.056	0.760	**0.021**
Evening	-1.584	0.675	-2.346	0.205	0.051	0.737	**0.019**
Day							
Ref: Weekend	–	–	–	–	–	–	–
Weekday	-0.425	0.372	-1.145	0.654	0.313	1.352	0.252
Reason							
Ref: Passive	–	–	–	–	–	–	–
Playground	0.890	0.383	2.323	2.436	1.153	5.205	**0.020**
Active	-0.118	0.464	-0.255	0.889	0.356	2.207	0.799
Threshold (cut point)							
Ref: Rarely	–	–	–	–	–	–	–
Rarely/Never	-2.446	0.943	-2.593				0.010
Never/Regularly	-1.174	0.927	-1.266				0.205
Fit statistics							
Likelihood ratio test[e]	***x^2***	15.06					
	p-value	0.0198					
AIC[f]	**304.58**						
McFadden R^2	**0.0471**						
Cox and Snell R^2	**0.0949**						
Nagelkerke R^2	**0.1079**						

[a.] The ordinal categories are: Never, rarely, regularly. [b.] SE: standard error. [c.] OR: Odd ratio.[d.] 95% confidence limits.
[e] Results of the likelihood ratio tests for comparing the full model and the null model. [f.] Akaike information criterion.

Lastly, together, the predictors of crowding perceived by others did not account for a significant amount of variance in the outcome, likelihood ratio χ2 (6) = 4.89, p=0.559 (Table 30). Overall, the model accounted for approximately 2% of the variance in the outcome, McFadden's pseudo-R^2 = 0.019. There are also no significant odds ratios.

Table 30. Ordinal logistic regression: Coefficients of model (Dependent variable: Crowding by others[a])

Variable	Coef.	SE[b]	T value	OR[c]	OR (95%)[d]		P value
Park Type							
Ref: Suburban park	–	–	–	–	–	–	–
Urban core park	-0.770	0.471	-1.635	0.463	0.182	1.158	0.102
Time							
Ref: Morning	–	–	–	–	–	–	–
Afternoon	-0.003	0.678	-0.005	0.997	0.262	3.755	0.962
Evening	-0.256	0.704	-0.363	0.774	0.193	3.067	0.996
Day							
Ref: Weekend	–	–	–	–	–	–	–
Weekday	-0.019	0.408	-0.047	0.981	0.440	2.185	0.717
Reason							
Ref: Passive	–	–	–	–	–	–	–
Playground	-0.155	0.420	-0.370	0.856	0.374	1.948	0.711
Active	0.226	0.514	0.440	1.254	0.458	3.454	0.660
Threshold (cut point)							
Ref: Rarely	–	–	–	–	–	–	–
Rarely/Never	-2.181	1.020	-2.138				0.033
Never/Regularly	1.148	1.003	1.144				0.253
Fit statistics							
Likelihood ratio test[e]	***x^2***	4.885					
	p-value	0.5587					
AIC[f]	**256.56**						
McFadden R^2	**0.0187**						
Cox and Snell R^2	**0.0318**						
Nagelkerke R^2	**0.0387**						

[a.] The ordinal categories are: Never, rarely, regularly. [b.] SE: standard error. [c.] OR: Odd ratio.
[d.] 95% confidence limits. [e] Results of the likelihood ratio tests for comparing the full model and the null model. [f.]Akaike information criterion.

5.4 Conclusion

To conclude, two analyses were conducted for this chapter: 1) bivariate analyses and 2) ordinal logistic regressions. While the findings indicate weak associations, they shed light on the variables that impact the attributes of park visits. Although data on gender and day of visit were collected, they were found to be insignificant and, therefore, excluded from the analysis.

The first bivariate analysis revealed that the variable significantly associated with park visit frequency is visit reason, as indicated by the significant chi-square test of independence. The second analysis identified four variables significantly associated with visit duration: 1) transport mode, 2) income, 3) time of visit, and 4) reason. The third analysis found three variables significantly associated with self-perceived park crowding: 1) transport mode, 2) visible minority group identification, and 3) park type. Fourth, the only significant chi-square test of independence was between crowding perception by others and park type. Transport mode, park type, and reason are found to be significant for two out of the four analyses. Additionally, visit duration and self-perceived park crowding are the two variables with the most significant chi-square tests of independence.

Four ordinal logistic regressions were conducted with frequency, duration, self-perceived crowding, and crowding perceived by others as dependent variables. The independent variables were park type, time, day, and reason. The ordinal logistic regressions were all significant, with the exception of crowding perceived by others. However, they are not significantly strong. Within these regressions, the only predictor associated with visit frequency. The time of the visit is also significantly associated with the duration of the visit. Lastly, visit time and reason are significantly associated with self-perceived park crowding.

The findings suggest that individuals who visit the playground tend to stay for a longer duration and perceive more crowding as compared to those who do not. This micro-data on park visits highlights that crowding indicators are rarely significant, suggesting that parks are not perceived as overly crowded. Therefore, this provides an opportunity to diversify park equipment and space to increase use. In addition, the factors that influence the duration of the visit and the perception of crowding vary depending on the time of day and the park's location. This further means that social connectivity or park activities influence how people use park space.

PART III: WHAT COMES FROM THIS RESEARCH

CHAPTER 6: RESULTS AND DISCUSSION

6.1 A return to the main research problem and objectives

The research set out to examine the relationship between park quality (design) and park usage, particularly how this relationship differs across levels of park accessibility in Greater Montreal. As an overall result, it can bring nuance to park crowding and use on both the metropolitan and local levels. First, we measured access levels and created a typology based on immediate proximity and potential park congestion. Second, the research looked at park quality and how park context affects park use and crowding. We characterized park crowding by measuring park visitors' presence and activities, both temporally and spatially, within the park perimeters in parks with different access levels. To put it differently, we looked at the number of visitors over time and park space. Although we did not set a threshold to evaluate crowdedness, we consider the spatial patterns of users represented by crowding. We also paid attention to park layouts and their role in determining crowding.

The following discussions are associated with the three preceding chapters. First, Chapter 3 focused on how the accessibility to parks varies across different population groups (e.g., low-income, visible minorities, children, seniors) in Greater Montreal according to park size/equipment. Second, Chapter 4 addressed how park crowding differs in function of park profiles and configurations. Third, Chapter 5 analyzed patterns of visit frequency, duration, and perception of crowding in Greater Montreal parks.

The key findings are summarized in Section 6.2 in the following chapter. Then, the findings from Chapter 3 regarding the notion of accessibility are discussed in more detail in Section 6.3. Section 6.4 explains and discusses the spatial patterns of park use, especially comparing the urban core and suburban parks. Additionally, Section 6.5 examines the factors that influence park frequency, duration, and the perception of crowding. Lastly, Section 6.6 concludes with the limitations and perspectives of the emerging research from this dissertation.

6.2 The main findings

The key findings in Chapter 3 highlight three ways to measure environmental equity in access to parks. Chapter 4 provides a methodology based on observation data that enables us to reveal fine spatial patterns of crowding in parks. Finally, in Chapter 5, visitors partaking in certain activities or at certain times perceive the park as crowded. Both Chapters 4 and 5 show that, overall, parks are underutilized in relation to different residential densities.

First, in Chapter 1, we combine spatial proximity and potential congestion to expand the notion of accessibility and refine the assessment of environmental inequities. In doing so, we find that the potential congestion of park equipment is more significant than the potential congestion of park areas in Greater Montreal. In addition, we find that DAs with significant percentage of children seem to have parks far from residential areas and a more congested in terms of facilities. Moreover, seniors do not seem to have any accessibility problems. Visible minorities and low-income households are more prone to parks with a high potential for congestion.

Second, in Chapter 2, we propose an observational methodology that can demonstrate how the park's facilities are intricately woven into park design, particularly when it comes to park crowding. Bivariate and visual analyses point to some determinants of park crowding, i.e., accessibility indicators (proximity and hectares per person), urban services near the parks (e.g., daycares), and park equipment. We also show that facilities attract all visitors, but a low presence of adolescents and seniors is observed in all parks. Furthermore, urban core parks offer less passive activity infrastructure but have more diverse uses and crowding than suburban parks.

Third, Chapter 3 provides survey data on the frequency, duration, and perception of crowding through observations and surveys. The findings suggest that individuals who visit the playground tend to stay for longer and perceive more crowding than those who do not. This micro-data on park visits highlights that crowding indicators are rarely significant, indicating that these parks are not perceived as crowded. As a result, this allows the opportunity to diversify park equipment and space to increase use. The factors that influence the duration of the visit and the perception of crowding vary depending on the time of day and park type. The findings add to the discussion of ways to calculate potential crowding beyond just surface area and equipment per capita.

Lastly, this dissertation has contributed to the field of park studies, specifically regarding location. It compares parks in urban areas with those in suburban neighborhoods in a large metropolitan area. Previous studies have been conducted in mid-sized cities or urban cores, such as in London, Ontario (Gilliland et al. 2006), Edmonton (Smoyer-Tomic, Hewko, and Hodgson 2004), and the City of Montreal (Reyes, Páez, and Morency 2014; Coen and Ross 2006; S. Moore et al. 2010). In contrast, this dissertation focuses on a large metropolitan area and compares parks within these limits.

The main findings will be discussed in the following sections, which will delve deeper into how this dissertation contributes to expanding accessibility, the spatial patterns of park use, and the future of park crowding and design.

6.3 Expanding the notion of accessibility: Urban core versus suburbs

Three ways to measure environmental equity in park access are proposed and tested. The first way is to separate the park proximity and congestion measures, and then only to consider the mean values of the two measures (weighted t-tests). This is a useful way for planners to rapidly estimate the magnitude of inequities. More specifically, in Greater Montreal, we show that seniors do not have differential access compared to the rest of the population (perhaps because the population of seniors is dispersed throughout the study area; see Figure 6). Children tend to live in areas further from parks but have more park space and facilities (typically in the suburbs, Figure 11). Low-income and visible minority populations are in the same situation: while living closer to parks, they suffer from congestion due to limited park space and facilities (typically in dense and central areas, Figure 11).

The second way to assess equity is by looking at how park access varies in function of the population composition (linear regressions). This analysis allows us to see which population group suffers the most, holding all other groups constant. In this case, the low-income population percentage had a strongly negative association with park congestion measures. The population proportion of visible minorities follows the same tendency but to a lesser degree. Compared with the t-tests, the regression results do not change for children (they are further from parks but have better facility provision) but change slightly for seniors (with significant associations to park measures, but generally favorable).

The third way (using multinomial logistic regressions) provides a more complex and nuanced portrait of park access in that it considers the demand (population size of the park) and the offer (park area and equipment) simultaneously. This analysis can tackle a specific problem of park access, e.g., low level of park proximity and high level of potential congestion park, for a specific group. The results here do not reveal inequity in seniors' access to parks. In contrast, the percentage of visible minorities is the only group that tends to live in areas characterized by both low accessibility and high potential congestion. Moreover, there are slight problems for children because of park distance. However, this suggests consistency in the three methods when no pronounced inequities exist. We underscore the need to integrate proximity and congestion when evaluating park access to provide appropriate solutions to inequities.

These findings are in line with recent park equity research, in which authors demonstrate that the presence of a park nearby does not always translate to an equitable distribution as park quality can also be unequally distributed (Maroko et al. 2009; Boone et al. 2009; Sister, Wolch, and Wilson 2010; Wolch, Wilson, and Fehrenbach 2005; Rigolon 2016). The results corroborate with a literature review of North American and European park access research from 1998 to 2014 (Rigolon 2016), pointing out that even if low-income individuals and visible minorities live closer to parks compared to wealthier populations, the parks are lower quality in terms of park maintenance and equipment.

Geographically speaking, potential park area congestion and potential park facility congestion are higher in inner-city neighborhoods than in suburban municipalities. The two park congestion indicators provide insight into the notion of carrying capacity, which is the number of visitors a park can support before deteriorating (Cohen et al. 2010). The indicators of potential park area and park facility congestion are insights into the notion of carrying capacity because it looks at the number of facilities or hectares by 1000 inhabitants. Therefore, when the carrying capacity is exceeded, this can accelerate the deterioration of park facilities and may discourage park visits for potential users, directly linked to potential carrying capacity.

These findings support the relevance of using several accessibility measures in park planning that draw on two dimensions of park access, i.e., park proximity and potential park congestion. As Talen (2010) put forward, a robust, evidence-based assessment of park distribution is necessary for park planning, design, and investment, especially from a “spatial logic” standpoint. More specifically, they propose three criteria: proximity (i.e., accessibility to parks on foot), social needs (more park access in areas with higher needs), and diversity (more parks in areas that are densely populated and functionally diverse). Although land use diversity was not considered in the measures, it is assumed that densely populated zones in the inner city usually have diverse urban functions. This study’s case of Greater Montreal clearly shows the disparities between the inner city and the suburbs along geographic accessibility levels, population size, and profiles. As such, it is hoped the three accessibility measures developed in this study will allow planners to assess the state of park provision and propose interventions according to Talen's (2010) three criteria.

6.4 Spatial patterns of park use: urban core versus suburbs

In this study, observation data enables us to reveal fine spatial patterns of crowding within parks, such as the separation of activities due to specific equipment (especially those allowing unique activities, such as sports or playgrounds). For example, we show that activities are more spatially separated in larger suburban parks with fewer users. Our observation data confirmed the typology of parks in function of their proximity and congestion that was computed based on spatial data from Chapter 3. More specifically, for three parks located in DAs with high proximity to residential areas in the urban core, we found high levels of park use in terms of frequencies of observed users and groups (Tables 12 and 17). Furthermore, in Hochelaga (the park located in a DA with high proximity coupled with high congestion due to the density of population surrounding the park), we found consistent use throughout the day and the week, as well as the highest levels of passive activity and individual visitors. In contrast, for the three parks located in DAs with a low level of proximity in the suburbs, we found very low park use and crowding despite their larger size compared to the urban core parks. Bariteau, one of these parks, has a slightly higher frequency of users because of a daycare nearby, and these peak hours of use denote higher crowding at the playgrounds. Bourbonnière experiences high crowding at the tennis courts but low use everywhere else. We found that the park's surrounding area matters as we saw an increase in park use to the daycare next to Bariteau.

To explain spatial patterns of crowding within the parks, three determinants are noted: park facilities, the park's context, and people's age. First, while the presence of facilities does not always increase levels of use due to factors such as condition and maintenance, we did find in this case that sports facilities are important aspects of parks that attract users. In parks like Bourbonnière, Chamberland, and Wilson, with different residential contexts, we can see consistent use of these facilities across the observation periods. This finding supports studies such as those of Cohen et al. (2010) and Gilliland et al. (2006), which underscored the importance of park facilities for park use. However, contrary to studies the results of Kaczynski et al. (2007), we did not see an elevated park use with more facilities. We saw users visiting Bourbonnière solely for sports and physical activity. Chamberland has similar facilities; nonetheless, we saw diverse uses and more visitors in the park than in Bourbonnière. Chamberland is in a dissemination area with the highest percentage of children ages 0-14 and 15-24 (Table 3). Despite lacking diverse equipment, Wilson and Hochelaga experience large numbers of visits. To put it differently, the larger number of facilities in the park did not always attract a larger number of visitors. This may result from park location, given that Wilson, Hochelaga, and Chamberland are found in dense neighborhoods, while homes with yards surround Bourbonnière.

Second, we found a more significant rate of passive activities (compared to active ones) in the urban core parks and a spatially and temporally consistent usage of the full-park area. Among these three parks, the most notable is Hochelaga, which has the most passive activity unrelated to child supervision (e.g., a larger presence of adults and individual park users). This could be due to the lack of private green spaces, such as backyards, in densely populated neighborhoods (Honey-Rosés et al. 2020; Rung et al. 2011). In suburban parks, crowding tended to be found when specific services or institutions were nearby (such as daycare). We hence corroborate previous research in finding that parks in lower-density areas, such as the parks in the suburbs, are less likely to experience crowding (Sister, Wolch, and Wilson 2010). This said, given the large rate of passive activity in our study parks, there is a need to provide park furniture for more passive use, such as seating areas in the shade, picnic tables, and swings.

Third, we highlight the lack of teenagers, young adults, and senior age groups within our six parks. This finding is similar to other studies that noted that these age groups were less observed in parks (Mehta and Mahato 2020; Li and Yang 2021; Cutts et al. 2009). This is a prime example of updating the park design to support diverse uses. Research has shown that adolescent park users prefer specific infrastructure. For example, playgrounds have been shown to attract adolescent park users if they are not only designed for young children (Veitch et al. 2017; Rivera et al. 2021; Van Hecke, Ghekiere, Veitch, et al. 2018). While Wilson had diverse seating options, its playground was busy with young children and provided very little distance between users. Furthermore, given gender differences, such as female adolescents' lower park use and higher reported safety concerns, it is important to incorporate diverse features, such as swings and playgrounds that are attractive to diverse age groups and spaced out enough to minimize conflict (Rivera et al. 2021).

A question that arises from the findings is 'What is the ideal crowing of a park?'. Two studies find that an 'ideal crowding' situation is important for increasing park use for all park users (Cohen et al. 2010) and seniors (Arnberger et al. 2017). For example, there is a controversy regarding teenagers' preferences towards crowding. Rivera et al. (2022) find crowded parks discourage teen users in Melbourne, Australia. This could be for several reasons; for example, adolescents want a space where they do not bother nor are bothered by others (Van Hecke et al. 2016). However, other work has shown that adolescents prefer highly visited parks due to security or popularity (van Aalst and Brands 2020). Therefore, when designing parks, the spatial configurations should provide enough space for all users and between users, in addition to including teens in the process, as highlighted by certain findings in Chapter 3. The section below examines the impact of visit frequency, duration, and perception of crowding on visitors' experiences in these six Greater Montreal area parks.

6.5 Visitors' behaviors and frequency, duration, and perception of crowding during park visits

The survey analysis allowed for micro-data on people's park visit tendencies and crowding perception. The three main takeaways from this study are 1) park activities (especially playgrounds and sports) prove to be the most important predictor in determining park duration, frequency, and crowding, 2) the time of visit is very significant for the duration and perception of crowding, and 3) the overall park area was underutilized in relation to the different residential densities; however, crowding is more perceived, though very minimally, in urban core parks and less in suburban parks. Overall, our findings corroborate observations from the previous section, as the most popular areas were sports-related or the playground. We also found that in relation to the previous finding, the overall park areas are underutilized as there are hotspots for visitation, and those are the spots most likely to be perceived as crowded. We discuss below our results with regards to previous studies.

First, we found that park activities are the most important predictors in determining duration, frequency, and perception of crowding. This aligns with the literature, as several studies show that frequency and duration depend on various reasons. For example, Misiune et al. (2021) in Vilnius, Lithuania, found frequent and rare visitors were enticed to visit parks for similar reasons: exercise and leisure. They also noticed frequent park visitors value nature more than those who visit less. Furthermore, in Tokyo, Japan, Soga and Akasaka (2019) found that park visits increased for individuals who valued nature and had more vegetation within the park. The duration also depends on the activity undertaken. In Bucharest, Romania, Iojă et al. (2011) found, while comparing dog walkers and other park users, that dog walkers were the most frequent park users, but other visitors spent more time in the park. Most users spent one to two hours in parks. Schetke et al. (2016) found similarities and differences between Karachi and Ho Chi Minh City. They found that park visit frequency and duration are lower in Karachi, particularly when it comes to activities and reason for the visit. Park users in Karachi spent less time and frequented fewer parks than in Ho Chi Minh City. However, the reason for visiting the park can help explain why users spend varying amounts of time in their respective parks. Schetke et al. (2016) found that in Karachi, park users' visited for natural elements, whereas Ho Chi Minh City park users preferred parks with diverse facilities.

Second, we found that the time of day is very significant for the duration and perception of crowding. Studies show that urban residents will travel to larger parks on the weekend and visit their local parks during the week (Li and Yang 2021; Bertram et al. 2017). This is due to time constraints, such as traveling and spending more time in parks. Interestingly, along the same lines, Bijker and Sijtsma (2017) found that people have a “portfolio” of places they enjoy. There are local stops that are favorites, rated low but visited often, and then more natural places that are a bit farther away are visited often. Time and day are essential factors in park visit frequency and duration. Studies show that urban residents will travel to larger parks on the weekend and visit their local parks during the week (Li and Yang 2021; Bertram et al. 2017). Regarding differences between urban contexts, Rossi et al. (2015) found that in Brisbane, Australia, in peri-urban contexts, older visitors live closer to the park while younger visitors travel to visit and are less frequent. This particular research focused on distance to national parks, and the authors find that these differences are due to the activities and the time or money cost to visit the park.

Third, the overall park area was underutilized in relation to the different residential densities; however, crowding is more perceived, though minimally, in urban core parks and less in suburban parks. This is related to a bigger question of densification. All six parks were underused outside of the playground areas. The role of population density and retail around parks have been highlighted in other studies (Veitch et al. 2020; Lyu and Zhang 2019). For example, Zhang and Li (2023) in Shenzhen, China, highlight the importance of the surrounding population density, which plays a significant role in the number of park visits. There seems to be general differences between parks in different urban contexts. Truong et al. (2023), in a study of the perceptions of primary school parents, find that different degrees of urbanization impact the perception of green space and park availability. According to the study's findings, the degree of urbanization significantly impacts parents' perceptions of available outdoor spaces. Specifically, as urbanization levels increase, parents report a decline in the availability of urban public spaces but an increase in access to parks. In Helsinki, Neuvonen et al. (2007) find that living in the suburbs, proximity, active transportation, and larger green space per inhabitant all increase park visit frequency. In addition, they found that including exercise sites within the parks did not increase or decrease frequency of use. However, a person's employment status is the main factor that decreases frequency, possibly due to decreased leisure hours.

It has been well-documented that the frequency of park visits decreases as the distance to the park increases (Schipperijn et al. 2010). Some studies have focused on distance as a non-specific variable. Studies such as Tu et al. (2020) in Beijing, China, have looked at different types of parks and visit frequencies beyond distance. In their research, they examine how the size of a park affects the relationship between distance and frequency of visits. They emphasize that travel time should not be considered a nonlinear variable when analyzing variations in park visit frequencies. Their findings reveal that when distance alone can no longer explain park visit frequency, other factors such as aesthetics, nature, and maintenance play a significant role in determining the visitor's choice of distance (Tu et al. 2020). Rossi et al. (2015) use a decay distance to address the impact of distance on park use and consider other factors. However, distance remains a strong point in deciphering park use frequency and duration. As shown in park accessibility studies, a park user's choice encompasses more than proximity; therefore, park use studies should aim to enlarge the variable that impacts frequency and duration.

6.6 Contributions and recommendations

This study's main contributions is its methodology, which involves three analyses of users' park presence across a metropolitan area. The dissertation's findings serve as a basis for recommendations, notably the need to rethink park design needs and funding allocations. It is worth noting that while this dissertation is not about the COVID-19 pandemic, there has been a heightened interest in understanding park usage, public space crowding, and park quality, which has led to park crowding issues in the central areas of many North American cities (Lennon 2021; Zhang and Li 2023; Liu and Wang 2021).

Due to COVID-19 restrictions in summers 2020 and 2021, parks became important public spaces for those who did not have private green space to access the physical, mental, and social benefits derived from parks (Honey-Rosés et al. 2020; Mitra et al. 2020). As a result, parks in areas with fewer hectares per 1,000 inhabitants became crowded as indoor sports and recreational activities shut down (Honey-Rosés et al. 2020). The pandemic demonstrated the lack of green public space to accommodate those in dense neighborhoods under social distancing rules (Honey-Rosés et al. 2020; Bristowe and Heckert 2023; Lennon 2021). Areas where people live in high-density built environments, where residents lack access to private outdoor spaces like backyards, could contribute to worsening environmental inequalities. This dissertation showed that people tend to see parks in densely populated areas as crowded and that minorities and low-income individuals tend to live near more potentially crowded parks. This emphasizes the need to provide adequate and well-designed park space in high-density areas, particularly in the aftermath of the COVID-19 pandemic, where crowding was a significant issue.

The following section provides three different contributions and their related recommendations. First, the study's methodological contribution is explored while delving into the multi-method design. Second, the lack of multifunctional and flexible park design, particularly in urban core neighborhoods, is highlighted. Third, the need for targeted interventions in funding allocations is recommended based on the crowding differences between urban core and suburban parks. The section ends with a discussion of the dissertation' limitations and future research.

6.6.1 Methodological contributions

This study's methodology is a valuable contribution to the field of park access and equity research as it offers a multifaceted approach to assessing environmental inequities and crowding. This study put forth a three-part multi-method design that acts as a funnel from the metropolitan level to the different profiles of parks based on different layouts and levels of accessibility and then to the individuals who frequent these parks. All three steps, as well as the complementary aspect of each method, are methodological contributions to the field.

First, the study proposes and tests three accessibility measures. By including the supply and the potential demand of park area (hectares) and equipment along with park proximity, we can enhance the understanding of the complex dynamics shaping park usage patterns. By further employing generalized linear models and multinomial logistic regression analyses, we analyzed park access variations based on population demographics, providing a nuanced understanding of which groups are most affected by inequities and offering a detailed portrait of park access disparities. This enables researchers to address specific issues, such as low park proximity and high congestion, for particular population groups.

Second, our systematic observations counter the abundant park accessibility studies that primarily use GIS-based computations of spatial accessibility to parks and various spatial data sources such as street networks, park location, and census data (Smoyer-Tomic, Hewko, and Hodgson 2004; Gilliland et al. 2006; Dai 2011; Ngom, Gosselin, and Blais 2016; De Alvarenga, Apparicio, and Séguin 2018; Cohen et al. 2010; Sister, Wolch, and Wilson 2010). The addition of the observations allows for a complementary and nuanced analysis of crowding as estimations on potential crowding are done by computing the park surface (and their equipment) per capita. We were thus able to analyze peak hours of use or equipment in a park, help identify popular areas and gain a deeper understanding of the intricacies of the concept. Our study characterized park crowding by measuring park visitors' presence and their activities, both temporally and spatially, within the park perimeters. This allowed us to pay attention to park layout and its role in determining crowding. As a result, we further developed observation methods and spatial analyses for park crowding.

Third, the last piece in this multi-method study design focuses on park users' perceptions and relationships with their parks. Surveys allowed us to pay attention to perceptions of crowding, mainly when and where, and this provided a nuanced look at crowding as we could see activity, duration, and length of visit. Altogether, we had hoped to inform urban researchers of a methodology capable of empirically measuring crowding and providing a nuanced understanding of its temporal and spatial variation within parks.

6.6.2 Multifunctional and flexible design

We show that the six parks were quite similar, suggesting their creation followed a similar planning and design process. Yet, a diversity of parks and equipment is important. Numerous global studies have explored park attendance and visitors to understand what draws individuals to parks and how far they are willing to travel for a visit (Schetke et al. 2016; Dawson et al. 2023; Soga and Akasaka 2019; Misiune, Julian, and Veteikis 2021; Schipperijn et al. 2010; Yuen and Jenkins 2020). Key variables to consider are frequency, duration, and perception, as they clarify the reasons and purposes behind park visits for those who were present. The duration of a person's stay in a park, for example, can provide valuable insight into its attractiveness and the amount of free time available (Schipperijn et al. 2010). This information is valuable in designing park layouts that offer a variety of activities and can accommodate visitors throughout the day. Correlations between these variables may vary depending on the visit's purpose, time, location, and distance.

Therefore, the implication of this study is not just about park design but about the potential design transformation of these spaces. As a result, we advocate for creating multifunctional parks that can truly accommodate the diverse needs of the residents. Given the current urban population growth and the growing environmental issues, cities are pressured to density for environmental and social reasons (Boyko and Cooper 2011). The idea of compact cities, or densification, comes with high density, mixed land uses, and different green infrastructures that can help combat urban sprawl (Monkkonen and Manville 2019; Neuman 2005; Tappert, Klöti, and Drilling 2018). This is for several reasons; densification has been held up as an ideal urban development to decrease energy consumption, decrease car dependency, and provide access to residents' daily interests (Mouratidis 2018; Neuman 2005; Lo and Jim 2012; Jim 2004; Lennon 2021). Often, the idea is to densify residential areas, eliminating a lot of private yards and replacing them with larger or more green spaces. Densification, ideally, would mean that parks are in proximity and, therefore, residents have a place to access leisure where, in many cases, greenspaces are extensions of the house (Lo and Jim 2012; Jim 2004; Lennon 2021).

However, some issues come with city densification, such as the lack of green space and the acceleration of gentrification (Ståhle 2010; Freemark 2020; Tappert, Klöti, and Drilling 2018). While the plan may be to add public green space when densifying cities, research has shown that an increase in densification decreases green space (Haaland and Van Den Bosch 2015) or causes existing ones to become crowded (Arnberger 2012). This is often due to urban parks or other green spaces' competition with other land uses during planning (Tappert, Klöti, and Drilling 2018;

Jim 2004). Studies conducted in Hong Kong have highlighted the issue of compact cities with limited green spaces. (Lo and Jim 2012; Tian, Jim, and Liu 2017). Within the process of densification, Haaland and Van Den Bosch (2015), green space loss has been significant in Asia and Australia, with less impact in Western Europe.

The phenomenon of compact cities has been observed to come at the cost of the loss of green spaces, which are often the first to be sacrificed due to the high land demand. This has led to the precarious existence of green spaces in urban areas. Increasing residential density can negatively impact the quality of public spaces due to increased usage (Honey-Rosés and Zapata 2021). A balance is needed since densification promotes well-knitted communities. However, some people will not be happy with the larger number of residents or events despite the city needing to densify certain areas to meet affordable housing or sustainability goals (Gabbe 2019; Honey-Rosés and Zapata 2021). This means that design and management must be capable of addressing densification in green spaces and recreational use (Chan, Si, and Marafa 2018; Shanshan Chen et al. 2021), especially the increased intensity of use when quality green spaces are sparse (Arnberger 2012).

We see that certain parks attract different people depending on their activities, and we can see this is the difference between weekdays and weekends. However, neighborhood parks are the parks that people spend time in during the week. Furthermore, we found that, besides the playground, most of the parks in our study are underutilized. However, we see that urban core visitors are more likely to perceive crowding, and they are more likely to perceive crowding during the evening. We also found that urban core parks offer less passive activity infrastructure. Compared to suburban parks, the urban core parks have more diverse uses in total; however, when looking at each individual park, there are not many multifunctional and flexible designs.

Multifunctional or multi-use (Talal and Santelmann 2021) are designed to simultaneously accommodate diverse groups of individuals or activities across time or within park space (Sundevall and Jansson 2020). Research on crowding within urban green spaces has been done by Arnberger (2012) in Vienna, who found, in particular with urban densification, that longtime residents reported recent adverse reactions to higher use due to urban densification processes. It is necessary to examine the park's interior and how to enhance it in response to the growing demand from dense neighborhoods to create park spaces that comfortably accommodate multiple activity groups without tension and align with sustainability goals, such as promoting biodiversity and addressing urban heat islands. Authors have highlighted that in suburban parks, this could look like adding vegetation or multi-use seating for gatherings (Rode 2016; Sundevall and Jansson 2020). In urban core parks, this could look like design features that highlight users' spontaneous changes to park use or playground layouts that are accommodating to adults (Herman and Drozda 2021; Mehta and Mahato 2020; Shaikly and Mella Lira 2023; Refshauge, Stigsdotter, and Cosco 2012). This flexibility empowers users to tailor their park experience (Loughran 2020; Herman and Drozda 2021), and multifunctionality can encourage longer visits (Refshauge, Stigsdotter, and Cosco 2012).

There is also a broader understanding that multifunctional parks can respond to different societal needs (social, economic, environmental) that can be integrated into park design (Calderón-Argelich et al. 2023; Rigolon et al. 2022). For instance, many multifunctional designs respond to different activities and demographic groups while supporting biodiversity or inclusivity (Hansen and Pauleit 2023). However, these different interests depend on park context or policy goals and will look different in each neighborhood. Furthermore, a multifunctional infrastructure vision can be incorporated at a policy scale to address multiple interests, such as gender mainstreaming or biodiversity (Calderón-Argelich et al. 2023; Hansen and Pauleit 2023). This approach offers a unique opportunity for urban planners and policymakers to reimagine and revitalize public spaces, making them more inclusive and accessible.

We underscore the importance of tailoring park planning and design to address specific age-related needs, as highlighted by disparities identified in the study. For instance, while seniors exhibit no significant differential access compared to the general population, they are absent from our observations; considerations for their unique preferences and limitations should be integrated into park design. Specific characteristics like passive activity infrastructure are crucial for encouraging park use among seniors and adolescents, suggesting avenues for improving park design to cater to diverse age groups (Rivera et al. 2021; Veitch et al. 2022). Studies have shown that crowding and policing are important indicators of adolescents' use of parks (Rigolon and Flohr 2014; Stanfield and Van Riemsdijk 2019). Research has shown that certain characteristics are important for seniors to have a pleasant stay in the park (Veitch et al. 2022; Klinenberg 2018). Our recommendation for multifunctional and flexible design is in line with studies in Vienna, Austria, and Malmö, Sweden, which found that multifunctionality and the division of park spaces were attractive to young adults and teen girls (Shaikly and Mella Lira 2023). The authors state that 'flexible movable furniture' allows teen girls to design the space themselves. The study's findings foster practical guidelines for the design and development of more inclusive and equitable park spaces. By identifying disparities in park use among different demographic groups, such as seniors, children, low-income individuals, and visible minorities, the study underscores the need for park design to address specific needs and preferences.

6.6.3 Targeted interventions in funding allocation

The last contribution and related recommendations are based on inequitable funding allocations. Our study found differences in park design and usage disparities between urban core and suburban parks. Our study indicates that the time of day and park location influence the duration of visits and the perception of crowding, with visitors more likely to perceive crowding in urban core parks than in suburban parks, particularly in the evening. Furthermore, urban core parks offer less passive activity infrastructure but have more diverse uses and crowding than suburban parks, with often increased visitors.

To address the discrepancies in park design and usage, we recommend implementing interventions in funding. The funnel characteristic, as well as the multi-method nature of this thesis, can help fund allocation decisions as it can identify mismatches between park offerings and needs. The E2SFCA and environmental equity assessment evaluates potential disparities between park size or number of facilities and the surrounding population. This could allow for targeted interventions with limited resources. Second, the assessment of park crowding through observations helps identify patterns of crowding and use of park facilities, which can help design interventions to either add facilities or create more appealing park layouts. By identifying the presence and absence of certain groups in parks, policymakers can prioritize resources toward interventions tailored to meet their unique needs. More particularly, the uneven tendencies of crowding and design between the parks should result in more equitable funding based on these disparities (Wolch, Wilson, and Fehrenbach 2005). Third, exploring park frequency, visit duration, and crowding on park perception helps capture the experiences of the park users that are harder to capture in the other two methods. This can help build a connection between planners, designers, and the community to ensure funding is allocated to meet the neighborhoods’ needs.

Lastly, certain urban core neighborhoods could use these differences as a basis to call for more targeted funding interventions (Rigolon, Browning, and Jennings 2018). We found parks lacking certain design measures to invite and support many park users at a time. Policymakers can ensure that interventions are responsive to residents' diverse needs and preferences, particularly in areas characterized by high congestion levels, by introducing diverse park facilities targeting passive and active activities for all ages.

6.7 Perspectives and limitations

The dissertation' limitations range from timeframe to the absence of certain sociodemographic groups within the data collected. The following perspectives and limitations provide lines for future research on parks and park use.

First, the study was done in a short timeframe and using a multi-method design. This funnel technique demonstrates that different methodologies are needed to understand park crowding and provide a snapshot of park usage during a popular season (summer). This approach may be critiqued for being too broad, too short, or unimportant enough to draw any conclusions. Future research can explore visitors' park preferences more in-depth, particularly via a more qualitative approach. Seeing why people do not visit their closest park would be interesting. This is similar to the conclusions of Bijker and Sijtsma (2017), who found that people have a portfolio of parks that they rotate within. A larger timeframe would be needed to identify repeated patterns over a few weeks and observing park use in the night could increase observations of other age groups.

Second, this study did not examine the impact of race, ethnicity, or gender due to insignificant regression results, which could provide valuable insights into further adapting park design to meet the current needs. Although we attempted to collect data on such topics, we did not receive enough data to make significant contributions. Studies have shown that perceptions are different, particularly based on gender and race. For example, in Cincinnati, Ohio, Mehta and Mahato (2020) find that park designs can create spatial segregation by excluding certain groups of users. They found that potential park users were underrepresented in the actual park users, and there needed to be more accommodation for the diverse population living adjacent to the park (for both age and race). Based on their observations, specific park spaces were used by different user groups, and they urged the consideration of such spaces in parks.

Moreover, regarding gender differences, girls' use of parks declines as they get older, and safety within the park is an important factor in park use for women and people of color, particularly when it comes to the inclusion and exclusion of a space (Shaikly and Mella Lira 2023; Byrne 2012). Nonetheless, studies moving forward should not essentialize gender roles or race in park use and focus on an intersectional analysis (Loukaitou-Sideris and Stieglitz 2002; Calderón-Argelich et al.

2023). Therefore, another line offuture research line focuses on increasing girls’ use in the parks, particularly factors that may inhibit girls' park use, such as safety and lighting (Talal and Santelmann 2021). Similarly, considering the findings in Cincinnati, Ohio, interventions aimed at fostering diversity and inclusivity in park spaces are crucial. This might involve implementing inclusive design features, such as diverse seating areas, water play zones, and multi-use open spaces, to cater to adjacent communities' diverse needs and preferences (Mehta and Mahato 2020).

Third, this study is not a dissertation on park history. Therefore, historical records of park planning and construction could also provide helpful information to better understand the causes of the underlying parks' quality and usage patterns. The evolution of parks can shed light on contemporary issues since each era of development is associated with different social problems, whether from epidemics to residential planning or access to nature in an industrialized setting (Loughran 2020). Not only does park design change over time, but these changes also reflect evolving recreational ideals (Cranz 1982; Gold 1972; de Laplante 1990). For example, American parks saw increased recreational facilities during the 1930s, where physical activities preceded former views of leisure and rest (Cranz 1982; de Laplante 1990). However, some would argue that a certain standardization of park design has been instilled in North American parks from the 1940s onwards by accommodating solely physical activities, which has left a void in contemporary park design to address the needs of diverse residents and activities (Cranz 1982; Loukaitou-Sideris 1995). In Montreal, park evolution follows a similar timeline consistent with North American history (de Laplante 1990). Future research could identify these trends and relate them to current planning discourses in the Greater Montreal area.

This study's multi-method design recognizes the limitations of a spatial analysis alone and advocates for future qualitative research to delve into park users' experiences and perceptions. To better understand park users' experiences and perceptions in areas characterized by high levels of park crowding, future qualitative research based on interviews and observations should be conducted. Our approach deepens our understanding of park access dynamics and informs more holistic planning and management strategies. Our three-step approach helps inform planners in providing enough park space and facilities to meet population needs. First, measures of potential park area and facility congestion can identify areas where consideration is needed. Second, the systematic observations further develop the ways of viewing crowding. This approach can help plan parks so facilities can reflect and be updated in relation to the surrounding population, increasing use without overcrowding or gentrifying. Third, our surveys began to break the surface into viewing park visitors and the perception of crowding. Altogether, this holistic approach advocates for tailored and flexible designed parks.

CHAPTER 7: CONCLUSION

This dissertation aimed to explore how park quality and park usage differ across levels of park access in Greater Montreal based on carrying capacity and functional density. It introduced an observational aspect to a study area that was otherwise focused primarily on spatial data. The study used three methods to address this objective: a spatial analysis, systematic observations, and a survey analysis.

The spatial analysis answers how park accessibility varies across different population groups in Greater Montreal according to the social context and the carrying capacity of the park's size and equipment. The systematic observations help discover how park crowding differs in different park profiles and usage patterns. Lastly, the survey analysis highlights how park characteristics influence the duration, frequency, and perception of crowding of park visits between suburban and urban core Greater Montreal parks.

As a result, the relationship between park quality and park usage differs across park access levels in Greater Montreal in three ways: 1) the number of facilities within the park is more significant than park acreage in the area, 2) the carrying capacity is not very crowded, based on the park's size, 3) regarding functional density, park visitors seem to view certain activities as crowded and not necessarily the whole park. These findings imply that there are differences between suburban and urban core parks and that once the notion of accessibility expands beyond proximity, there are other details that must be examined.

These results can further support policies and design for parks that can cater to a diverse range of users and activities in order to provide an urban space that is useful for both local residents and visitors. Specific attention should be given to adolescents and seniors to help increase their park use. This approach can help planners and designers update park infrastructure to better meet the needs of park users and surrounding residents, moving away from a one-size-fits-all approach. This is especially important in urban core parks, given the elevated use and crowding that we found. Incorporating data regarding park usage patterns and crowding within design today will create more equitable parks that improve the urban quality of life and update the role of parks in creating just and sustainable cities.

Although this study aimed to include aspects of gender identity, race, age, and ethnicity in relation to park use, the results were inconclusive. Moreover, the survey had limited responses, and a more extended observation period in the park could have led to a larger survey sample for a more comprehensive analysis. However, this study provides a snapshot of park use, which is beneficial for testing methodologies. Further research can focus on personal issues related to crowding by using more survey responses or longer surveys that center on social demographics. Other methods could include walk-alongs, community planning guidelines, and longer-form interviews. Nonetheless, this dissertation opens the door for conversation on exploring park crowding spatially, observationally, and personally in a large Canadian metropolitan area.

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