

**Growing a Rooftop Revolution**  
**Repurposing Urban Roofs for Increased Food Production in Montreal, QC**

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## Abstract

In the past few decades, environmental and social realities have led to a heightened interest in how food is grown, processed, distributed, and accessed. Rooftop gardens may offer a sustainable solution for underutilized urban space, and supplement access to healthy and affordable food. Montreal, QC served as a case study comparing three buildings with rooftop agriculture; however, this research was also structured to provide lessons and insights on rooftop food production that could be applied more broadly.

An in-depth look at types and scales of rooftop agriculture, the barriers to developing a rooftop garden in Montreal, climate conditions, and policy context will be presented and synthesized to help inform similar efforts in other locations. In doing so, this thesis will begin to develop a framework for rooftop urban agriculture that can lead to more food secure and productive cities.

**[Keywords: Rooftop, Urban Agriculture, Food Security]**

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## 1.0 Introduction

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In 1974, a devastating fire burned down much of the Centre Sud area in Montreal, destroying 140 homes (Montreal Gazette, 2015) and causing an estimated \$2 million (\$9.67 million in 2019) in damage (New York Times, 1974), impacting many residents living in the historically low-income neighbourhood (Montreal Gazette, 2015). A few months after the wreckage, the City established a community garden on a damaged site for agricultural production with the intent to increase food security for nearby residents (Montreal Gazette, 2015). As a result of the Centre Sud garden's success, in 1975 the City introduced a municipal gardening program and provided land for urban agriculture purposes (Bhatt & Farah, 2016). The community gardening program has since expanded into 18 of the City's 19 boroughs (administrative community boundaries), making urban agriculture a more conventional method of food production and increasing food security in Montreal (Ville de Montreal, n.d.-a). While the municipal gardening program does not yet include rooftops, it has nonetheless encouraged more food production within the city limits. Given land constraints, in recent years a growing number of organizations are using rooftops for food production and this research explores differences in how organizations create and manage rooftop gardens within the City of Montreal and their impacts on local food security.

### 1.1 Problem Statement and Research Questions

While there are different models for addressing food insecurity within Canada, rooftops seem to be an underutilized and under-researched resource. With the current global environmental realities of climate change and their impact on food production (United Nations, n.d.), there is a clear need for the coordination and development of alternative food sources in Canadian cities.



Through the critical investigation and assessment of three RA projects in Montreal, this practicum intends to fill gaps in the existing literature and provide a thorough set of recommendations for how to develop successful RA as a conventional method of food production in Canada. To achieve these objectives, this practicum seeks to answer the following research questions:

- 1) What are the different methods (agricultural processes) and characteristics of RA and how are they appropriate for different scales of RA?
- 2) What are the benefits of growing food on rooftops? How do these benefits differ by the methods identified in question 1?
  - 2a) What are the community-level benefits of RA?
  - 2b) How much food is produced, how is this measured, and who gets it?
  - 2c) What are the goals of these cases, and are they able to achieve these goals?
- 3) What are the most significant factors in creating and sustaining a rooftop garden in Montreal, Quebec?
  - 3a) What are the barriers or constraints related to the process of creating a rooftop garden, e.g., cost, planning, policy, structural, and others?
  - 3b) How do these barriers or constraints vary between different methods and scales of RA?

## **1.2 Research Objectives and Significance**

Generally speaking, Canada has a sufficient supply of food (Statistics Canada, 2017-a). The supermarkets are well stocked with a large variety of produce from all over the world at all times of the year. Generally, a lack of food is not the cause of hunger for many Canadians. The issues lie in terms of access, distribution, and cost of healthy food (PROOF Food Insecurity Policy Research, 2016). There are many ecological, economical, and social challenges related to the current food

system in Canada (more on this in Section 3.1) (PROOF Food Insecurity Policy Research, 2016). As mentioned previously, a large amount of our food is coming from international destinations. While this is a privilege, it is also energy intensive, environmentally harmful, and results in increased costs and often a lower quality of food (Kissinger, 2012). RA may be a solution to help alleviate some of the issues surrounding the existing Canadian food system (Dubbeling & Massonneau, 2014). Foods that are grown locally contribute to the local economy, can be culturally appropriate, in-season, and can be harvested and distributed fresh, ensuring a higher quality of healthy food.

### **1.3 Document Structure**

This practicum begins by introducing the reader to the context of the research problem and addresses why the City of Montreal was selected as a case study. Following this is a literature review that explores the current state of food security in Canada and in Montreal. To explore how RA can help address food insecurity, a review of literature about RA types, history, benefits and critiques, and types of food items commonly grown on rooftops is studied. Next, the research methods used in this practicum are outlined and are paired with each of the research questions they intend to answer. The research findings will then be discussed. This section first explains the site analyses of each of the selected case study sites: not-for-profit, private, and commercial RA projects. The section goes on to address the different types of agriculture methods being used, food items being grown, amount of food being produced, barriers to creating a rooftop garden, and the different municipal policies that impact the development of a rooftop garden in Montreal. The recommendations section explores different collaboration, infrastructure and policy interventions that the City of Montreal could implement to encourage more RA projects. Finally, some conclusions are drawn for the City of Montreal relating to policy implications for RA

and neighbourhood planning and design. The implications for the structure of buildings, green roof and local food policies, measuring the success of RA, implications for grocery stores and planning practice, and lastly, opportunities for further research.

## 2.0 Site Context

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### 2.1 Montreal as a Case Study

Cities that experience frigid winter conditions tend to face more challenges in facilitating and maintaining year-round rooftop gardens. Nonetheless, a few winter cities have managed to overcome these obstacles, and others are attempting to do the same. Montreal, Quebec serves as a case study and was selected as a Canadian winter city that has a growing interest in the development of RA projects. The agricultural efforts on three sites have been examined in a comparative case study; each site has a different organizational structure – one not-for-profit, one private, and one commercial project. They have been evaluated to inform planning efforts in other regions, particularly in Canada.

### 2.2 Montreal, Quebec

Located on an island in the St. Lawrence River, Montreal is the second largest and one of the oldest and most historic, but fastest growing cities in Canada (Ville de Montreal, n.d.-b). The city of Montreal is made up of 19 boroughs spread across 365.65 km<sup>2</sup> (Ville de Montreal, n.d.-b). Montreal's boroughs are more than just neighbourhood boundaries, they are administrative boundaries within the city that each have their own self-government and planning regulations

#### *Montreal Demographics*

In 2016, Montreal's population was 1,704,694, an increase of 3.3% since the 2011 Census. The

population density per km<sup>2</sup> was 4662.1 (Statistics Canada, 2016-a), which can be compared to other major cities including Vancouver (5492.6) (Statistics Canada, 2016-b), Toronto (4334.4) (Statistics Canada, 2016-c), and Winnipeg (1518.8) (Statistics Canada, 2016-d).

Montreal has one of the highest percentages of low-income citizens in Canada, with 22.7% of the population falling below the low-income line (Statistics Canada, 2016-a), compared to Toronto (20.2%) (Statistics Canada, 2016-b), Vancouver (18.8%) (Statistics Canada, 2016-c), and Winnipeg (15.9%) (Statistics Canada, 2016-d) (see Table 1). However, Montreal is also one of the most affordable cities in Canada. The monthly cost of housing is relatively low compared to other cities in Canada; meanwhile, the hourly minimum wage is quite similar. In Montreal, the average monthly cost for owned dwellings is \$1,337, while the average monthly cost for rented dwellings is \$835 and minimum wage is \$11.25 (Statistics Canada, 2016-a). These numbers can be compared again to Vancouver (\$1,714 (owned), \$1,296 (rented), \$11.35 (min. wage)) (Statistics Canada, 2016-b); Toronto (\$1,682 (owned), \$1,242 (rented), \$11.60 (min. wage)) (Statistics Canada, 2016-c); and Winnipeg (\$1,158 (owned), \$938 (rented), \$11.15 (min. wage)) (Statistics Canada, 2016-d) respectively.

Canadian City	Population	Population Density (people/km <sup>2</sup> )	Low-Income (% of pop.)	Minimum Wage (\$/hr.)	Cost of Housing (\$/month) (Owned; Rented)
Montreal	1,704,694	4662.1	22.7%	\$11.25	\$1,337; \$835
Toronto	2,731,571	4334.4	20.2%	\$11.60	\$1,682; \$1,242
Vancouver	631,486	5492.6	18.8%	\$11.35	\$1,714; \$1,296
Winnipeg	705,244	1518.8	15.9%	\$11.15	\$1,158; \$938

Table 1: Montreal Demographics Compared to Other Canadian Cities (Based on data from Statistics Canada, 2016-a, b, c, d)

### ***Montreal Culture and Heritage***

Montreal's rich culture and heritage is in part attributed to the challenge of building around the St. Lawrence River, and the protection of various heritage building styles that evolved from different periods of urbanization (Ville de Montreal, 2004). The majority of Montreal's established heritage sites are concentrated around the adjacent Ville-Marie and Cote-des-Neiges-Notre-Dame-du-Grace boroughs (Ville de Montreal, 2004). There are currently seven designated heritage sites, although the Montreal Master Plan indicates an additional nineteen sites scattered around Montreal that will be considered for heritage designation in the future (Ville de Montreal, 2004). The City of Montreal recognizes the value and continues to make culture and heritage preservation and enhancement a priority (more on this in Section 6.5.1) (Ville de Montreal, 2004).

### ***Montreal Climate***

Montreal's weather varies substantially over the course of the year. As a city with four distinct seasons, average temperatures range from -12 degrees Celsius in the colder months, to +26 degrees Celsius in the warmer months (Fig.1) (Google Weather; NOAA). Precipitation remains relatively consistent in Montreal throughout the year, with only 69.8mm in February to a maximum of 111.9mm in December (Fig.2) (Google Weather; NOAA). Snowfall typically occurs from October to April, with the greatest snowfalls in December, January, and February averaging 620.4mm, 428.1mm, and 441.5mm, respectively (Fig.3) (Google Weather; NOAA). The hours of daylight range in Montreal depending on the season. The summer months experience the most daylight, typically around 15 hours, while the winter months only experience around 9 hours of daylight every day (Fig.4) (Google Weather; NOAA).

Temperatures (°C)

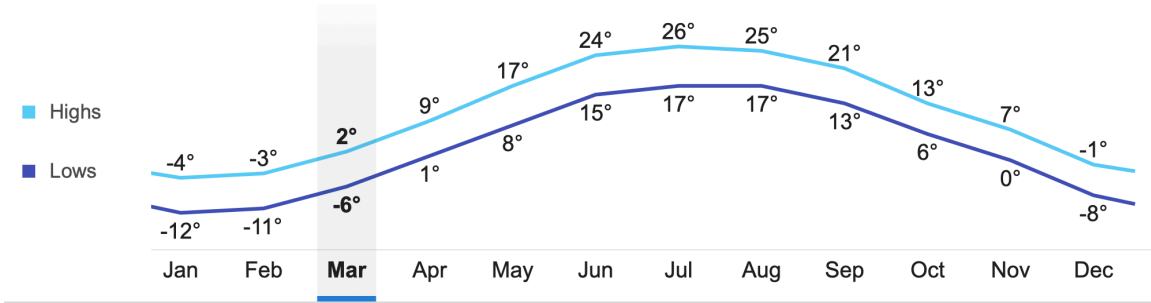


Figure 1: Montreal Average Temperatures (Google Weather; NOAA)

Rainfall (millimetres)

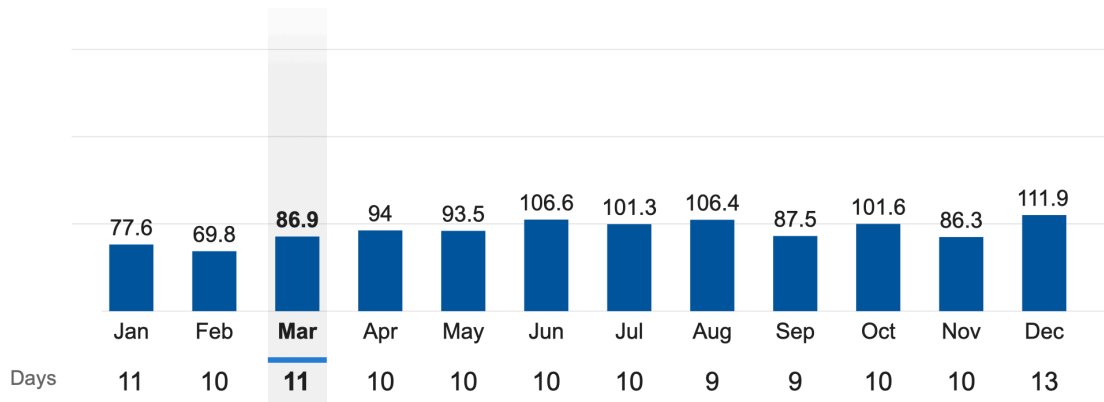


Figure 2: Montreal Average Rainfall (Google Weather; NOAA)

Snowfall (millimetres)

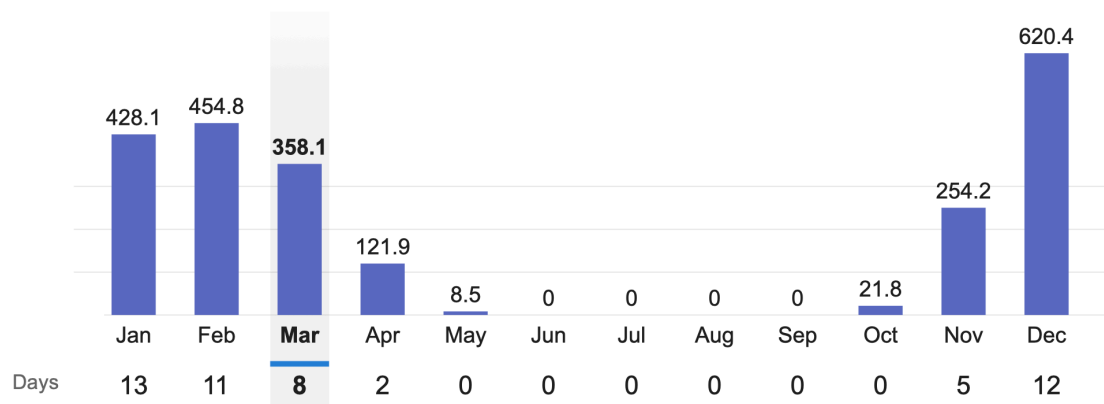


Figure 3: Montreal Average Snowfall (Google Weather; NOAA)

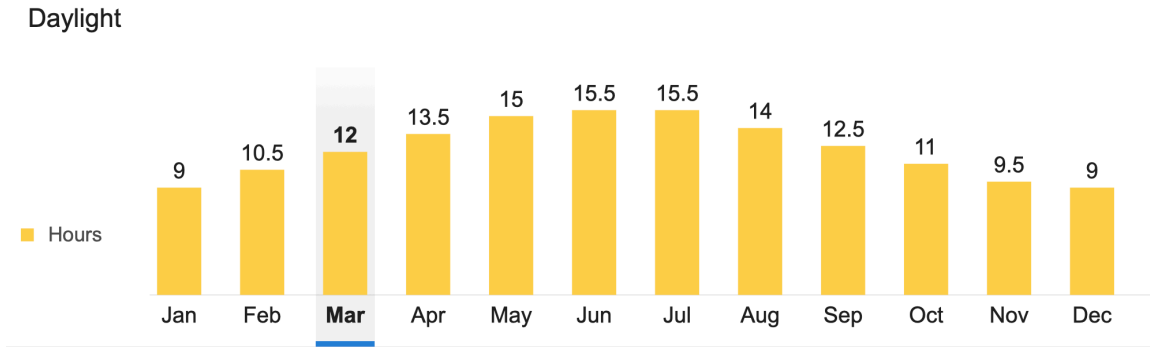


Figure 4: Montreal Average Daylight (Google Weather; NOAA)

While these average temperatures have been relatively consistent over the last few decades, they are expected to change in the future as a result of climate change. The city of Montreal is making serious efforts to anticipate and respond to these changes (Ville de Montreal, 2004). These efforts can be found in many planning documents including *Montreal's Sustainability Plan 2016-2020* (Ville de Montreal, 2016-a) and *Climate Change Adaptation Plan 2015-2020* (City of Montreal, 2017).

*The Sustainability Plan 2016-2020*, which identifies the first sustainable development challenge as reducing greenhouse gas (GHG) emissions by 80% by the year 2050 (Ville de Montreal, 2016-a). Four interventions have been identified to work towards a more sustainable Montreal: reduce dependence on fossil fuels; add vegetation, increase biodiversity, and ensure the continuity of resources; ensure access to sustainable, human-scale and healthy neighbourhoods; and, make the transition toward a green, circular, and responsible economy (Ville de Montreal, 2016-a).

*Montreal's Climate Change Adaptation Plan 2015-2020* mentions the extreme heat waves, flooding and freezing rain that the city has experienced in the past few years and that have caused a great deal of property damage and financial costs (City of Montreal, 2017). The report also summarizes climate projections made by Ouranos, a climate consulting group,

regarding temperatures, precipitation, destructive storms, drought, river floods, and heat waves (City of Montreal, 2017). The report expects that Montreal will continue to experience higher average temperatures, an increased frequency and intensity of heavy rainfalls, more frequent and lengthy heat waves, an increase in destructive storms, longer periods of drought, and more intense spring river floods (City of Montreal, 2017).

### **2.3 Urban Agriculture in Montreal**

Despite its immoderate climate, Montreal's urban agriculture movement is growing and has become a core part of the city's character since the 1970s (Fairholm, 1999). As a winter city that has successfully brought food production into the confines of the city, Montreal's experience could help inform similar efforts in other locations.

In 1974, during a two-and-a-half-day firefighter strike known as the Red Weekend, a devastating fire burned down much of the Centre Sud area in Montreal, destroying 140 homes (Montreal Gazette, 2015) and causing an estimated \$2 million (\$9.67 million in 2019) in damage (New York Times, 1974). The fire impacted many residents living in the historically low-income neighbourhood (Montreal Gazette, 2015). A few months after the wreckage Peter Borque, who was the Director of Botanical Gardens at the time, met with many of the displaced families to help establish a community garden on a burnt down site where they could now grow food (Montreal Gazette, 2015). As a result of the Centre Sud garden's success, less than a year later the City introduced a municipal gardening program and provided land to many low-income and displaced residents (Bhatt & Farah, 2016). The garden movement continued to grow in the 1990s due to an influx of immigrants and in 2002 after some municipal reorganization, the City passed along the responsibility of managing the gardens onto the respective boroughs (Ville de Montreal, n.d.-a). As of 2017, there were 97 operating community gardens in 18 different



boroughs, each of which is led by a volunteer committee to oversee administrative matters (Ville de Montreal, n.d.-a).

Urban Agriculture in Montreal Timeline	Event
1974	Devastating fire during a firefighter's strike known as the Red Weekend destroyed over 140 homes and displaced many low-income families
1975	In response to the fire, the City established its first official community garden: Centre-Sud
1990s	Montreal community gardens began expanding
2002	Montreal borough's take responsibility for managing their own district's gardens
2017	Montreal community gardens have grown to 97 across 18 boroughs

Table 2: Urban Agriculture in Montreal Timeline (Based on data from Ville de Montreal, n.d.-a)

## 2.4 Rooftop Agriculture in Montreal

More recently, because of limited productive land and increasing support from the City's planning and sustainability directives, RA has become a central component of Montreal's urban agriculture movement. In fact, the City has made several commitments in recent urban and sustainable development plans. The City's *Master Plan* for example, identifies adding vegetation to the roofs of buildings in a long-term effort to support healthier urban development (Ville de Montreal, 2004). More recently, planning directives such as the City's *Sustainability Plan* also prioritizes "increasing vegetation, biodiversity, and the continuity of resources" (Ville de Montreal, 2016-a, p. 9).

### 3.0 Literature Review

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“Each person, each community, each society, each generation throughout history has built its own habitat with the aim of satisfying a particular way of life.” (Guallart, 2014)

RA can be defined as the “cultivation of plants, animals, and fungi on rooftops for the purpose of human use and consumption” (Mandel, 2013). The following themes emerged within the literature to give insight on RA, and how it might be a useful tool for urban food production.

#### 3.1 Food Security

The World Food Summit 1996 stated that “food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (Food and Agriculture Organization (FAO) Agricultural and Development Economics Division, 2006, p. 1). Food insecurity, on the other hand, is the inadequate or uncertain access to food with finances being the largest contributor (Tarasuk, Mitchell, & Dachner, 2012, p. 1).

In Canada, 4 million people (almost 11% of the total population) and in Montreal, more than 137,000 (about 8% of total population) are affected by food insecurity (Tarasuk, Mitchell, & Dachner, 2012). There is a wide range in the source of income for those experiencing food insecurity. For example, the majority (62%) of food insecure households receive wages, salaries, or are self-employed; 16.1% are on social assistance; 12.3% receive a senior’s income; 6.4% receive another source of income or none at all; and 3% rely on employment insurance or worker’s compensation (Tarasuk, Mitchell, & Dachner, 2012, p. 11). Additionally, household

composition ranges for those experiencing food insecurity. For example, 15.6% of food insecure Canadian households are with children under the age of 18 (34.3% of which consist of a single female parent, compared to 17.2% of male single parents); 11.4% of food insecure households are without children under the age of 18; and 7% of elderly living alone experience food insecurity (Tarasuk, Mitchell, & Dachner, 2012, p. 10).

Several factors can lead to food insecurity. Individually, food insecurity is most commonly attributable to income. However, when looking at the global food system, changes can be a result of extreme climate fluctuations (flood or drought), natural disasters, urbanization (loss of arable land), and an increase in transportation costs (Government of Canada, 2018). The United Nations recently released that the Global Food Price index rose for the second consecutive month and will likely continue to fluctuate in the coming years mainly due to the risk of droughts, flooding, and other climate-related changes (United Nations, 2018).

While low productivity and high costs will continue to be contributing factors to global food insecurity, by starting to rely more heavily on locally-sourced foods, city dwellers may be able to protect themselves from experiencing these periods of fluctuation and uncertainty (Ackerman-Leist, 2013).

*Canada's Food Security Strategy* focuses on three priorities, which include food assistance and nutrition, sustainable agricultural development, and research and development (Government of Canada, 2018). Food assistance and nutrition aims to support organizations by providing needs-based funding in order to provide food to people in need. This approach helps temporarily but does not address the underlying issues. Canada's second priority, agricultural sustainability, means a food system that meets the nutritional needs of both existing and future populations while following three primary goals: a healthy environment, economic profitability, and social and economic equity (Feenstra, n.d.). Canada aims to design better processes that build the capacity

of small-scale farmers so they can continue to provide stable local sources of nutritious food (Government of Canada, 2018). Lastly, the efforts made toward agricultural research and development in Canada will give farmers better access to innovative, cutting edge technologies and the specialized expertise they need for their operations to run smoothly (Government of Canada, 2018).

### ***Food Security in Canada***

Generally, Canada has a plentiful supply of food with well-stocked grocery stores and fresh produce year-round. Food prices are also relatively affordable, with Canadian households spending an average of \$8,784 (or an average of 10.4% of their annual expenditure) on food per year (Statistics Canada, 2017-b). Yet, food insecurity is still a growing concern for many Canadians. Currently, one in eight Canadian households (over 4 million people) are considered food insecure (Tarasuk, Mitchell, & Dachner, 2012). Health Canada states that “Food insecurity exists within a household when one or more members do not have access to the variety or quantity of food that they need due to lack of money” (Roshanafshar & Hawkins, 2018).

There are ongoing economic, ecological, and social challenges in Canada’s food system that can lead to food insecurity. Even the smallest changes in the food system can impact the availability of food, economic and physical access to food, food utilization (i.e. nutritional value and variety) and the stability of all of these dimensions over time (Food and Agriculture Organization (FAO), 2008).

Food insecurity is a problem that can negatively impact physical, mental, and social health, and it creates a financial burden on the Canadian Healthcare System (Tarasuk, Mitchell, & Dachner, 2012). Statistics Canada categorizes food insecurity by the level of severity: marginal, moderate, or severe (Tarasuk, Mitchell, & Dachner, 2012).

Level of Food Insecurity	Definition
Marginal	Worry about running out of food or only having a limited selection, commonly because of financial reasons.
Moderate	Compromise on quality and quantity of food because of financial reasons.
Severe	Skip meals and reduce food intake.

Table 3: Levels of Food Insecurity and Definitions (Based on data from Tarasuk, Mitchell, & Dachner, 2012).

Food insecurity in Canada is often blamed simply on low income or periods of financial instability. However, it is important to examine the relationship of the overall food system and its impact on food security. The food system includes “all elements (environment, people, inputs, processes, infrastructure, institutions, markets and trade) and activities that relate to the production, processing, distribution, marketing, preparation and consumption of food and the outputs of these activities, including socio-economic and environmental outcomes” (United Nations, 2015, p. 1).

Data on food security in Canada is collected by Statistics Canada via the *Canadian Community Health Survey* (CCHS) (Tarasuk, Mitchell, & Dachner, 2012). The survey collects information from about 60,000 Canadians each year from all provinces and territories (Tarasuk, Mitchell, & Dachner, 2012). The survey is comprised of eighteen questions, seeking answers to the severity of food insecurity, household composition, and main sources of income. Some of the questions include how often people worry about running out of food, how frequently they are concerned about having enough money to buy more, if they are able to afford balanced meals, if there are children in the household, and frequency of smaller or skipped meals, among others

(Statistics Canada, 2018). While the CCHS does not include the entire Canadian population, it asks a variety of questions that give us an indication of the status of food security in Canada.

In 2016, agriculture contributed \$111.9 billion to the gross domestic product (GDP), accounted for almost 7% of Canada's total GDP, and represented almost 13% of Canada's total employment (Government of Canada, 2017). Canada is one of the world's largest exporters of agricultural commodities and agriculture is a valuable contributor to the country's economy.

To remain one of the world's largest agricultural exporters, Canada experiences a growing demand for agricultural land. Just over 6% of the country's land is used for agricultural production (Food and Agriculture Organization (FAO), 2016). By ensuring that new developments stay within the city limits, existing agricultural land may be protected. Additionally, by integrating more agriculture within cities, perhaps in the form of RA, Canada may be able to ensure agriculture continues to be a major contributor to the economy and may ultimately improve the country's resilience to food insecurity.

### ***Food Security in Montreal***

It is estimated that 137,000 people (about 8%) are currently affected by hunger in Montreal (Moisson Montreal, 2018). Moisson Montreal, Canada's largest food assistance organization, currently has 57 employees and recorded 97,352 volunteer hours in 2017, but still was only able to meet 60% of Montrealer's needs (Moisson Montreal, 2018). This food insecurity is not a result of food being physically unavailable, many people simply cannot afford it.

In April 2018 the Quebec government released their new policy to encourage development in the province's food sector (Montreal Gazette, 2018). The policy unveiled the government's contribution of \$5 billion into Quebec's food industry, with main goals to increase organic and homegrown food products. Currently, over half of the food purchased in Quebec is

locally sourced, and the remaining items are imports from other provinces or countries (Montreal Gazette, 2018).

Even if Quebec manages to increase the amount of food produced locally, it is difficult to say if Quebec can grow a wide enough range of products to meet the nutritional diversity standards and become entirely self-sufficient. Additionally, organic food is typically more expensive than non-organic food. Therefore, Quebec's new policy's approach to increasing organic food actually may not be helping the province increase local food security. Homegrown food, on the other hand, is more affordable because the cost of labour is not counted into the cost of food, it is simply available to the homeowner/gardener in exchange for their time. Homegrown products may actually increase food security within Quebec; however, many individuals have no experience with growing or harvesting their own produce.

### **3.2 History of Rooftop Agriculture**

#### ***Urban Agriculture***

Food has been grown in urban areas for thousands of years. There is evidence that goes back as far as 3100 BCE. However, recent history shows that food production was the basis of most early North American settlements, and planners often reserved a community space or "common" for urban agriculture (UA) (Hodgson, Caton Campbell, & Bailkey, 2011). Early signs of organized UA were found in the Allotment Gardens of Germany, originating in 1800 CE (Mandel, 2013). These urban gardens were created in response to the widespread hunger and poverty that many European countries faced over two hundred years ago during a time of rapid industrialization (Drescher, 2001). They were designed in clusters throughout the city, and a single garden allotment was typically between 600 and 1200 ft<sup>2</sup> in size (approximately half of a tennis court) and included a small shed on the site to store the necessary gardening tools

(Drescher, 2001). The first community gardens in Canada were the Railway Gardens, which operated from 1890-1930 (Fairholm, 1999). These gardens were operated by the Canadian Pacific Railway (CPR) and were located in town stations across Canada (Fairholm, 1999). In response to food shortages during World War I and II, the U.S. Government urged urbanites to create edible gardens which they referred to as Victory Gardens (sometimes also referred to as war gardens) (Hodgson, Caton Campbell, & Bailkey, 2011). Similar UA movements across North America responded to the effects of the Great Depression in the 1930s (Hodgson, Caton Campbell, & Bailkey, 2011). After World War II, most of North America experienced an economic boom and accelerated urban growth, which resulted in land competition and zoning changes, and ultimately, pushed agriculture production further outside of cities (Hodgson, Caton Campbell, & Bailkey, 2011). In 1973, the City of Seattle initiated the p-patch gardening program (Mandel, 2013). The Department of Neighborhoods now oversees 88 garden sites throughout the city, varying in shape and size (Government of Seattle, n.d.). In 1990, the “Organic Revolution” arose on the island of Cuba (Mandel, 2013) in response to the political and economic isolation that resulted from the Soviet collapse (Warwick, 2001). Cuba faced substantial changes during this time, the most significant being access to fresh food (Warwick, 2001). More than half of the foods that Cubans were eating prior to the Soviet collapse were imported, and once all trade was cut off between Cuba and the United States, Cubans faced difficulties and had to take full advantage of their resources; therefore, creating innovative programs for food production (Warwick, 2001). The Soviet collapse led to an eighty percent reduction in fertilizer and pesticide use across the country, which resulted in changes to the produce grown, and led to what is now known as Cuba’s Organic Revolution (Warwick, 2001). As of 2005, more than 30% of Cuba’s food is produced in cities (Mandel, 2013).



While this history is by no means extensive, it illustrates that UA movements have arisen within cities across several continents, over a few hundred years. As indicated previously, almost every UA movement around the world originated out of necessity in response to historical, and often devastating events. In more recent years, there has been a shift in UA's history. Food production in cities has been sprouting up to *protect* cities from experiencing future devastations, rather than *responding* to them. Evidently, UA is not a new movement, but it is becoming a well-known and more conventional method of food production that is expected to increase over the next decade, ultimately leading to more resilient and productive cities (Hodgson, Caton Campbell, & Bailkey, 2011).

### ***Rooftop Agriculture***

RA originated much later than UA; however, it is by no means a new method of food production. The first recorded signs of RA date back to the early eleventh century BCE, a Persian poet recorded roof gardens atop fourteen-storey buildings in the historical city of Fustat, Egypt (Richardson & Jacobs, 2011). In 600 BCE in what is now present-day Iraq, there may have been Hanging Gardens resembling something similar to a rooftop garden (Mandel, 2013). While there is little evidence to support the Hanging Gardens of Babylon and some believe it is purely mythical (Wilson), the story of rooftop food production persists. After recordings of the Hanging Gardens of Babylon, there seems to be a gap in history spanning over two millennia where little evidence of RA is available. The Palazzo Piccolomini in Pienza, Italy built in 1459 is perhaps one of the first examples of rooftop gardens in the Renaissance (a period in European history between the 14<sup>th</sup> and 17<sup>th</sup> centuries) (Osmundson, 1999). Starting in the 1600s, Norwegians were covering their roofs in sod (grass) as a form of insulation (Magill, Midden, Groninger, & Therrell, 2011). In 1926, the Swiss architect Le Corbusier coined his famous "Five Points of a New Architecture,"

mentioning that roofs should be always be flat and include a garden replacing the space that is now occupied by the building (ArchDaily, 2018). In the 1930s, the Rockefeller Centre in the United States built the first modern green roofs on various floors of the building (Magill, Midden, Groninger, & Therrell, 2011). As of 2005, Singapore was producing more than 20% of all food above grade (Mandel, 2013). In 2008, the Uncommon Ground rooftop garden in Chicago, United States is the world's first food producing rooftop to gain organic certification (Uncommon Ground, n.d.). In 2011, the world's first commercial rooftop greenhouse opened in Montreal, Canada (Lufa Farms, n.d.-a). Within the same year, Gotham Greens, the first rooftop commercial greenhouse in the U.S. opened and is currently the largest in the world (Gotham Greens, n.d.).

As indicated by RA's sparse history, around the beginning of the twenty-first century the world was seeing a proliferation of local food production, and there became a rapid development of RA. Although there are RA projects happening around the world, the movement is predominately led by Canada, the United States, and Singapore (Mandel, 2013).

Rooftop Agriculture Timeline	Location
1001 – 1100 BCE	Fustat, Egypt
600 BCE	Iraq
1459	Pienza, Italy
1600s	Norway
1926	Switzerland
1930s	United States
2005	Singapore
2008	Uncommon Ground, Chicago, USA (first organic RA)
2011	Lufa Farms, Montreal, Canada (first commercial RA)
2011	Gotham Greens, New York City, USA (largest RA)

*Table 4: Rooftop Agriculture Timeline*

### 3.3 Benefits of Rooftop Agriculture

Rooftop gardens, a niche within UA, offer many benefits that contribute to the environment, physical and social health, the local economy, and food security. Firstly, there are a few options for producing food on rooftops: container gardens, raised beds, intensive gardens (where the actual roof becomes the planting surface), and hydroponics (Nowak, 2004).

Considering the various options for RA food production, there are types that can appeal to those with different budgets, time and space constraints, and to suit differing structural capabilities of buildings. RA practices may also offer other benefits such as providing greater storm water retention, building insulation, and reduction of the urban heat island effect by absorbing sunlight. The patchwork ecosystems may also provide temporary habitat for species

that may otherwise be pushed out of cities (Mandel, 2013; Nowak, 2004). Such species include, but are not limited to, birds, butterflies, and insects such as bees.

Aside from structural and environmental benefits of RA, it can also significantly and directly improve the quality of life for people living in dense urban environments. For example, RA produces food locally, meaning that the distance produce needs to travel is substantially reduced, remaining fresh and retaining its maximum nutritional value (Mandel, 2013). From a social standpoint, RA provides plenty of opportunities for strengthening family and community bonds, the local food system, and personal reconnections and understandings of food production (Mandel, 2013).

The local economy can benefit from rooftop food production. RA keeps food production profits within the local economy, it provides access to jobs, and it can save individuals money when they grow their own produce (Mandel, 2013). RA also has the potential to eliminate mild to extreme cases of poverty and hunger (Mougeot, 2005). According to Mougeot (2005), there is evidence to show that RA significantly contributes to the urban food supply and household food security. In Canada, over seven million (or one in five) people are living in food deserts – areas where “access to affordable, healthy, and fresh food is significantly limited” (Fast Company, 2015, p. 1). In contrast, the World Bank has defined food security as “access by all people at all times to enough food for an active healthy life” (Mougeot, 2006). According to many scholars and noted authorities in RA (Fox, 2011; Johnson, 2010; Mandel, 2013; Smith, 2014), urban rooftop food production provides several benefits that may just be the answer to many of the problems currently being faced in cities across the globe.

### 3.4 Critiques of Rooftop Agriculture

With any concept comes criticism. In the case of RA, a still-developing movement, there are critiques and issues that may continue to arise. In some areas of the world, UA is viewed as a socio-economic problem because it is associated with urban land squatting (Mougeot, 2005). Other uncertainties associated with UA and RA include potential health and environmental risks such as particulate matter (e.g. dust and pollen being suspended in the air), former site uses (e.g. sites used for industrial or commercial purposes with contaminated soil), and the site's proximity to urban pollutants (e.g. emissions from heavily trafficked roads) which may make it unsuitable for agricultural production (Hodgson, Caton Campbell, & Bailkey, 2011). Some scholars believe that it is impossible to feed a city solely through UA but are not disregarding the UA movement (Viljoen & Bohn, 2014).

Another critique regarding RA is their reliance on food policies. There must be significant cooperation between public decision makers, related to planning, trading, land rights, and other food-related entities (Viljoen & Bohn, 2014). RA practices can potentially lead to land-use conflicts, such as: poorly managed or neglected sites, the use of pesticides and fertilizers, and the keeping of poultry and livestock, which often leads to complaints of excess noise and odor (Hodgson, Caton Campbell, & Bailkey, 2011). There may also be limited access to rooftops, for example those that are located on privately operated buildings may allow limited, if any, access to the general public. Additionally, the cost associated with establishing a structurally sound roof for agriculture may be unaffordable for new or small-scale organizations. While more of a challenge than a critique, both UA and RA can experience insufficient access to water and funding, thereby presenting significant challenges that may hinder the success of the garden, making it unsuitable for many locations (Hodgson, Caton Campbell, & Bailkey, 2011).

### **3.5 Types of Rooftop Agriculture**

There are several types of RA, and the reason for using a specific type depends on various factors: objectives for cultivation (e.g. educational, not-for-profit, private use, community, or commercial), the technologies applied (simple or advanced), the type of building the RA is on (e.g.: detached house, apartment, or industrial), and climate considerations (Orsini, Dubbeling, Zeeuw, & Gianquinto, 2017). For the purposes of this practicum, special attention will be paid to the types of RA commonly used for cultivation in the three case study sites: private, community (sometimes not-for-profit), and commercial.

#### **3.5.1 Private**

- Private RA may be defined as food production for a particular person or group of people.
- Common types of private RA include home gardens, amenities for employees, or food production for a restaurant or institution.
- This type of RA does not typically have profitability as the main goal (Orsini, Dubbeling, Zeeuw, & Gianquinto, 2017).
- Methods used in private RA are commonly soil-based systems and typically include container gardening, raised bed production, orchard production, vineyard production, and apiculture (Mandel, 2013; Orsini, Dubbeling, Zeeuw, & Gianquinto, 2017).

#### **3.5.2 Community**

- Community RA is food production that is dedicated to a particular social cause and does not operate with the main objective to make a profit.

- Common types of these RA projects include, but are not limited to, gardens run by non-profit organizations and social housing projects, or publicly-accessible gardens for food production, education, outreach, and socializing (Orsini, Dubbeling, Zeeuw, & Gianquinto, 2017).
- Methods used in community RA are typically soil-based or soil-less and commonly include: containers, raised beds, row farming, aeroponics, aquaponics, aquaculture, orchards, vineyards, livestock, dairy, and apiaries (Mandel, 2013).

### 3.5.3 Commercial

- Commercial RA typically has a main goal of high-yield production and profitability.
- Many commercial rooftop farms are found atop large office or industrial buildings, and typically include a greenhouse to protect crops for year-round, high-yield production (Mandel, 2013).
- Methods used in commercial RA may be soil-based or soil-less and commonly include: raised beds, row farming, hydroponics, aeroponics, aquaponics, orchards, livestock, or apiaries (Mandel, 2013).

The table below shows the most common methods of RA, identifying the appropriate scales for each method: small-scale, medium-scale, and commercial-scale (Table 5).

Rooftop Agriculture Type	Scale of Production
Container Gardening	Small, Medium
Raised Beds	Small, Medium, Commercial
Row Farming	Medium, Commercial

Hydroponics	Commercial
Aeroponics	Medium, Commercial
Aquaponics	Medium, Commercial
Aquaculture	Medium
Livestock Farming	Medium, Commercial
Dairy Farming	Medium
Orchard Production	Small, Medium, Commercial
Vineyard Production	Small, Medium
Apiculture	Small, Medium, Commercial

*Table 5: Rooftop Agriculture Types Categorized by Varying Scales of Production (Mandel, 2013, p. 25)*

Evidently, there are several types of RA choices available depending on the main objective of the garden. However, it is quite common that agriculture projects are transformed from one type to another to accommodate for changes in cultivation goals: e.g. gardens that experience a high demand and need to increase their growth capacity and may be limited by space or resources.

### **3.6 Food Items Being Grown on Rooftops**

The most common methods for growing food on rooftops include container gardens, raised beds, row farms, and hydroponics (Mandel, 2013). For the purpose of this practicum, only common crop examples for these four methods will be provided (Table 6).

Growing Method	Crop Examples
Container Gardening	Arugula, basil, bok choy, broccoli, brussels sprouts, cabbage, cauliflower, chard, chives, cilantro, collards, cucumbers, daikon, eggplant, endive,



	fennel, garlic, green beans, kale, kohlrabi, lavender, leeks, lettuce, mint, mizuna, mustard greens, napa cabbage, okra, onions, parsley, pears, peppers, pole beans, radicchio, radishes, rosemary, runner beans, rutabaga, shallots, snap peas, snow peas, sorrel, spinach, squash, thyme, tomatoes, toma tillos, zucchini
Raised Bed Production	Arugula, basil, beets, bok choy, broccoli, brussels sprouts, cabbage, cauliflower, carrots, celery, chard, chives, cilantro, collards, cucumbers, daikon, eggplant, endive, fennel, garlic, green beans, kale, kohlrabi, lavender, leeks, lettuce, mint, mizuna, mustard greens, napa cabbage, okra, onions, parsley, pears, peppers, pole beans, potatoes, radicchio, radishes, rosemary, runner beans, rutabaga, shallots, snap peas, snow peas, sorrel, spinach, squash, sweet potatoes, thyme, tomatoes, tomatillos, turnips, zucchini
Row Farming	Arugula, basil, beets, bok choy, carrots, celery, chard, chives, cilantro, collards, cucumbers, daikon, eggplant, endive, fennel, garlic, green beans, kale, kohlrabi, lavender, leeks, lettuce, mint, mizuna, mustard greens, okra, onions, peas, peppers, pole beans, potatoes, radicchio, radishes, rosemary, runner beans, rutabaga, shallots, snap peas, snow peas, sorrel, spinach, squash, sweet potatoes, thyme, tomatoes, toma tillos, turnips, zucchini
Hydroponics	Arugula, basil, bok choy, cabbage, chard, chives, cilantro, collards, cucumbers, eggplant, endive, fennel, kale, leeks, lettuce, mint, mizuna, mustard greens, napa cabbage, onions, parsley, peppers, radicchio, radishes, rosemary, shallots, sorrel, spinach, sweet potatoes, thyme, tomatoes, toma tillos, zucchini

Table 6: Food Items Being Grown on Rooftops (Mandel, 2013, p. 58)

### 3.7 Conclusions

The access to and production of local food is a major environmental and social issue of this generation (Ackerman-Leist, 2013). More than five billion people are expected to live in urban areas by 2030; therefore, access to local agricultural land will continue to diminish, greenhouse gas (GHG) emissions continually rise, and there will become an ever-growing need for innovative and sustainable food production, as well as reduced shipping, processing, and storage costs (Lim & Liu, 2010). Based on the literature reviewed, it is evident that RA is not a new, but instead a

growing method of food production that has its own set of challenges; however, many of them can be avoided with careful consideration and collaboration. While RA is not a panacea, it is however one of the many solutions to improve food security in Canada. RA proves to be beneficial for human's social and physical health, the environment, the local economy, and a secure food system. When used in combination with other urban, rural, and international food systems, RA has the ability to cultivate sustainably sound, resilient, and productive cities.

## 4.0 Research Methods

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A variety of research methods were used to gather and analyze information to answer the research questions (Table 7). Montreal, Quebec is used as a case study for this practicum, and the main research methods used included site analysis and document analysis. Structured interviews were intended to compliment the answers; however, there were challenges implementing this method (see Sections 4.4 and 4.5 for more information).

Qualitative research may be defined as that which “properly seeks answers to questions by examining various social settings and the individuals who inhabit these settings” (Gray, 2004, p. 6). According to Gray (2004), qualitative research can provide descriptive information that can inform the sequence of events leading to a particular result. He writes that, “qualitative data is (or should be) a rigorous and logical process through which data are given meaning” (p. 319).

There are many options for gathering qualitative data, and many researchers often use a combination of methods in one project (Gray, 2004). This practicum follows this same course of action by drawing on a few different methods in order to collect, analyze, and interpret data pertaining to this research project with the hopes of informing others. Since qualitative research

is occasionally criticized for being non-scientific and lacking in certainty (Berg, 2001) this practicum uses quantitative data, when appropriate, to supplement findings.

Research Question	Research Method
<p><b>1) What are the different typologies and characteristics of rooftop agriculture?</b></p>	<p>Site Analysis, Document Analysis, *Structured Interviews</p>
<p><b>2) What are the benefits of growing food on rooftops? How do they differ by the above-noted typologies?</b></p> <p>2a) What are the community-level benefits of rooftop agriculture?</p> <p>2b) How much food is produced, and who gets it? How is this measured?</p> <p>2c) What are the goals of these cases, and are they able to achieve these goals?</p>	<p>Document Analysis, *Structured Interviews</p>
<p><b>3) What are the most significant factors in creating a rooftop garden in Montreal, QC?</b></p> <p>3a) What are the barriers or constraints related to process (e.g. cost, planning, policy, structural, and others)?</p> <p>3b) How do these barriers or constraints vary between different types of rooftop agriculture?</p>	<p>Document Analysis, *Structured Interviews</p>

*Table 7: Chart Outlining Research Questions and Corresponding Research Methods*

\*Note: There were limitations to conducting Structured Interviews as part of this research (see Sections 4.4 and 4.5 for more information).

#### **4.1 Comparative Case Study**

The most significant component of this research is a comparative case study of three rooftop gardens. Case studies are commonly used in qualitative research, and they are particularly useful when a researcher is exploring the relationship between an experience or project, and the context in which it is occurring (Gray, 2004). This practicum explores the potential of RA for improved food security in Montreal, Quebec. The set of questions directing this research can be found in Section 4.0. Three cases in Montreal, Quebec were selected, all with different organizational structure to inform this research: one private, one community, and one commercial RA project. It was decided that three case studies were necessary in order to gain a deep understanding of the different scales and methods of RA.

Montreal makes for a suitable case study as it has developed several successful RA projects at various scales. In looking at Montreal and the existing RA projects, the research reveals differences in how organizations create and manage rooftop gardens in the city. The comparative case study approach allows the analysis to examine different features of three cases that can be generalized and applied to the rest of the RA movement in Montreal.

#### **4.2 Site Analysis**

Site analysis was conducted to address the first research question in Section 4.0, which aims to determine the characteristics of buildings and neighbourhoods surrounding RA projects, and how these characteristics relate to the respective types of RA present.

The site analysis gathered information concerning the characteristics of the built form surrounding the RA projects. This analysis documented if/how people access the rooftop, surrounding community demographics, specific site dimensions, land use, and the overarching planning documents influencing each of the three case studies.

In addition to text, photographs were used as a source of qualitative data. Photographs can provide a detailed recording of facts and physical conditions (Gray, 2004). For this practicum, photography was used to supplement the field research. The photographs are helpful for recalling events or for capturing evidence during the research process (Gray, 2004). Photographs are used to provide examples of RA infrastructure, as well as its context within the nearby urban fabric. While photographs can be a useful supplement to research, there are ethical considerations that must be addressed. In this practicum, photographs were used in ways that provide low ethical risk. No individual faces are visible in images, and images are only used to communicate physical aspects of the three case studies in Montreal, Quebec (see Ethics in Section 5.0 for more information).

The site analysis involved:

- Identifying the type and characteristics of the RA project; and
- Identifying the type of urban characteristics that surround the RA project, including access to the rooftop, site dimensions, the surrounding demographics, land use, and planning documents influencing the respective Borough

The analysis was conducted using:

- Google Maps satellite imagery;
- Photographs received from the case study site or an online source;
- Personal photographs taken on site visits; and,
- Review of the City of Montreal's Master Plan and Zoning Bylaw

### **4.3 Document Analysis**

Document analysis was used to gain a deeper understanding of the barriers or constraints related to developing and maintaining a RA project pertaining to cost, planning, structure, and policy.

This research evaluates the need for policies to support RA initiatives; therefore, policy documents were reviewed and analyzed to understand the details which help projects succeed in Montreal, Quebec. *Montreal's Master Plan*, various city policies, and borough zoning bylaws were used to shape this portion of the research.

### **4.4 Structured Interviews**

As part of the comparative case study, structured interviews among planners, academics, urban and agriculture activists were intended to be used as a means of primary data collection.

Unfortunately, only two interviews were conducted as respondents were unable to be reached through multiple attempts of communication. Instead, document analysis was used as a primary research method given difficulty in getting responses from the case study sites.

### **4.5 Limitations**

There are three main limitations associated with this practicum: there is no data to support exactly how many rooftop gardens there actually are in Montreal; there were only two structured interviews conducted; and Montreal is a predominately French-speaking city, therefore many planning documents are only available in French.

#### ***Data on Rooftop Agriculture in Montreal***

The data found on RA in Montreal is non-exhaustive as it is based on a review from internet sources. Many RA projects in Montreal are private and vary in scale (e.g. small container gardens

to entire rooftop gardens), and there is no public data available on them. The majority of the RA projects listed online are community or commercially operated.

#### **4.6 Biases**

This project was carried out by a researcher who is in favour of RA as a method of food production in urban environments. Despite the researcher's interests, this practicum included both benefits and criticisms to RA and was intended for the purpose of exploring RA's viability as a method of food production for improving local food security. Additionally, there is a bias related to the data sources used as this practicum uses only published materials or official documents.

#### **5.0 Ethics**

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Researchers have an ethical obligation to their colleagues, study participants, and to the larger population (Berg, 2001). That being said, most of the research for this project involved document review. However, interviews were intended to be conducted with key figures, such as planners and urban farmers in Montreal. Therefore, ethics approval was acquired, and all ethical standards were followed. Gray (2004) outlines the actions that can be taken for conducting ethical interviews, and the research adhered to these standards. In *Research Methods* (Section 4.0), some of the potential ethical issues surrounding the use of photography are discussed. Aside from the photography and two interviews, the majority of research was conducted by document and literature review; therefore, posing no serious ethical concerns.

## 6.0 Findings

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### 6.1 Site Analysis

This comparative case study includes three sites in Montreal, Quebec: one private, one community, and one commercial RA project. A review of the areas surrounding the projects and details about the boroughs that each of these case sites are located in shows relatively distinct urban contexts. The findings discussed below have been organized based on each of the aforementioned case study sites.

#### 6.1.1 Private

**Name of Organization:** Fairmont The Queen Elizabeth Hotel

**Goal:** Produce enough fresh vegetables and herbs to serve in the Hotel's restaurants

**Address:** 900 René-Lévesque Blvd W, Montreal, QC

**Borough:** Ville-Marie

**Zone:** 0004

**Land Use Designation:** M.7C (Mixed-Use)

**Building Height:** 120 m. The typical allowable building height for this zone is between 16-44m; however, the site is located within a special planning area that permits controlled, additional building heights. Having said that, no building in the Ville Marie borough may exceed the height of Mount Royal's summit which is 232.5 m above sea level.

#### *Site Introduction*

The rooftop at the Fairmont Queen Elizabeth represents the private rooftop case study and is located in the Ville-Marie borough. Built in 1958, the Fairmont Queen Elizabeth is a historically



significant building and luxury hotel in downtown Montreal. With 950 guest rooms situated on top of the Central Station railway (Fairmont, 2018), the building was designed to eliminate vibrations from trains passing below to keep their local and international guests happy (Fairmont, 2017). Aside from guest rooms, the hotel is a major conference centre and dining destination, including a restaurant, bar, café, and urban market.

The hotel experienced a \$140M renovation in 2017, modernizing the entire building and slightly changing the previous rooftop garden (Papineau, 2018). The size of the garden was slightly reduced to accommodate the new conference centre on the top floor; however, the hotel plans to expand their growing capabilities with vertical gardens (Papineau, 2018). Since opening, the hotel has continued to promote local cuisine, supporting and partnering with community organizations, local farmers, or growing their own vegetables and herbs to serve in their restaurants and urban market (Papineau, 2018).



*Figure 5: Fairmont Hotel Rooftop Garden (Image provided by Papineau, 2018).*

### ***Demographics***

As of 2016, the Ville-Marie borough had a population of 89,170 people across 16.5 km<sup>2</sup> and a population density of 5397.7/km<sup>2</sup> (Ville de Montreal, 2018-a). There are 51,430 private households with an average number of 1.7 people per residence, and the median annual income is \$25,486 (Ville de Montreal, 2018-a).

### ***Land Use***

The Ville-Marie borough is located in Montreal's downtown in a mixed-use area. The surrounding land uses are predominately mixed use, but do include some residential, green spaces, and institutional land uses (Fig. 6).

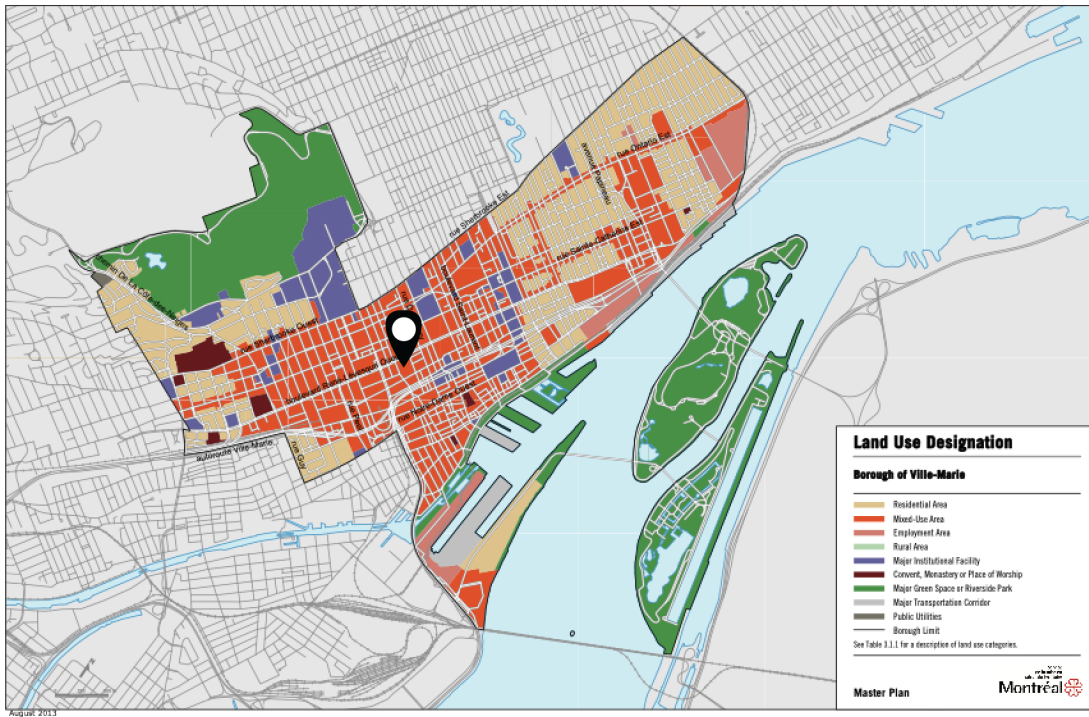


Figure 6: Private Case Study - Surrounding Land Use (Ville de Montreal, 2013).

### **Climate**

The rooftop garden on the Fairmont Queen Elizabeth is not enclosed; therefore, it is exposed to the elements and only operates during the warmer months: June to October (Papineau, 2018) (see more on Montreal's climate in Section 2.1).

### **Type of RA, Food Production and Recipients**

The Fairmont rooftop garden uses raised beds and smart pots for vegetable, herb and edible flower production (Papineau, 2018). Currently, the garden is growing a variety of herbs and edible blooms, cucumbers, melons, peppers, spinach, and kale used in the restaurants and has eight beehives producing honey that is sold in the hotel's urban market (Papineau, 2018). The Hotel's goal is to produce only enough vegetables, herbs, and edible flowers to serve in the

Fairmont Queen Elizabeth Hotel's restaurants and honey to sell in the gift shop. Therefore, the hotel produces low annual yields of 105.65kg (on average). The size of the garden has been reduced since the recent renovation (it is significantly smaller since a rooftop event space has been introduced), so the amount and variety of produce has also been reduced (Papineau, 2018). As the garden is now working with limited space, it has plans to expand with space-saving vertical gardens in the future (Papineau, 2018). The Hotel still keeps the weight of harvest but as they now have less vegetables and more herbs and edible flowers, they cannot accurately compare to previous years. As flowers are costly, this is where the Fairmont finds a lot of value and savings for their restaurant's produce costs.

### ***Access to Rooftop***

There is an elevator that provides access to/from the roof for transporting materials (such as the raised beds, smart pots, or soil) and produce. Since the Fairmont Queen Elizabeth garden is privately operated, few people regularly access it. The main visitors are chefs from the hotel's restaurants, the occasional guests who have requested special permission for a tour, and beekeepers (Papineau, 2018).

### ***Site Dimensions***

The rooftop garden space is a total of 800 sq. ft., but the growing surface is less than half of that, which includes five 4 ft. by 8 ft. raised beds and six smart pots (Papineau, 2018).

## Revenue Sources

As a small-scale and privately-operated rooftop garden, all operating costs come from the Fairmont Hotel itself, and the produce is used in their restaurants and sold in the urban market for-profit (Papineau, 2018).

## Planning Context

Along with the City of Montreal's Master Plan, the Ville Marie Borough has established useful plans that help guide development in the area, including a Sustainable Development Action Plan and a Food Strategy Action Plan.

The *Sustainable Development Action Plan* identifies challenges specific to the area, as well as a number of goals to address those challenges including: reduction of GHG emissions and fossil fuels; greening, increasing biodiversity and ensuring the sustainability of resources; ensuring access to sustainable neighbourhoods on a human scale and in health; making the transition to a green, circular, and accountable economy; and mobilizing stakeholders (Ville-Marie, 2016-a). Action 5 in the *Sustainable Development Action Plan* aims to "increase the greening of the built environment" by continuing to implement sections of the urban planning by-law so that new buildings are landscaped with green elements (Ville-Marie, 2016-a, p. 8). The Plan also suggests that the Ville-Marie borough needs to advocate for projects integrating sustainable development by establishing balances in terms of density and landscaping around projects (Ville-Marie, 2016-a). Action 11 in the Plan aims to integrate UA as a more distinct feature of the borough's identity (Ville-Marie, 2016-a).

*Ville-Marie's Food Strategy*, adopted in 2016, hopes to influence the fight for local food security and promote healthy eating. Areas of intervention include food production, food access,

promoting the acquisition of food skills, managing residual materials, and mobilization and governance (Ville-Marie, 2016-b). Over the next few years, the borough plans to work toward softening the regulatory framework by allowing more agricultural activities in the area and by encouraging the installation of roof terraces or gardens when a flat roof is rehabilitated or constructed (Ville-Marie, 2016-b)

### **Regulatory Context**

Ville-Marie's by-law has two main sections that influence the ability to implement rooftop gardens in the borough: rules relating to the height of buildings, and open space requirements for buildings that were built after the year 1994.

Firstly, there are mentions which regulate the height of buildings. The height of a building is calculated from "the natural grade to the building's highest point" (Ville de Montreal, 2001-a, p. 6). There are some exceptions which allow a relaxation to the maximum building height. Section 21 mentions that no construction other than a chimney, vent, elevator shaft or stairwell may exceed the maximum allowed building height (Ville de Montreal, 2001-a). This applies to the private rooftop case study, as guests use an elevator to access the rooftop garden. The construction which exceeds the maximum height must also have a minimum setback along the main roadway that is at least twice the height of the construction (e.g. if an elevator shaft is 10 feet tall, the minimum setback required is 20 feet) (Ville de Montreal, 2001-a). Any rooftop extension must be approved based on its location, appearance and ability to blend with or complement nearby buildings (Ville de Montreal, 2001-a).

The Bylaw requires buildings completed after 1994 that cover more than 85% of the property area to have open spaces (Ville de Montreal, 2001-a). The amount of open space required must be at least 10% of the total floor area of every dwelling unit, up to a maximum of

10 m<sup>2</sup> (108 ft<sup>2</sup>) per dwelling unit (Ville de Montreal, 2001-a). This required open space may be provided in the form of a lot, balcony, terrace, an interior public space, or a garden that is accessible to the residents (Ville de Montreal, 2001-a).

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### 6.1.2 Community

**Name of Organization:** Santropol Roulant

**Goal:** To increase local food security, community development, and social inclusion (Santropol Roulant, n.d.).

**Address:** 111 Rue Roy E, Montreal, QC

**Borough:** Plateau-Mont-Royal

**Zone:** 0342

**Land Use Designation:** H.2-4 (Residential)

**Building Height:** Allowable height on this site is 0-12.5m. The project's host building is 2 stories or approximately 8m.

#### *Site Introduction*

Santropol Roulant, a not-for-profit organization, represents the community RA case study (Fig. 7). In 1995, Santropol Roulant was created to provide “meals-on-wheels” for youth and senior citizens. The organization has grown over the years to include RA, providing employment and engagement opportunities, as well as fresh meals using produce from their three gardens: McGill University garden, Senneville Farm, and Roulant Rooftop (Santropol Roulant, 2018-a). For the purposes of this practicum and the site analysis section, only the Roulant rooftop and surrounding area have been analyzed.



Figure 7: Community Case Study - Santropol Roulant Rooftop Garden (Santropol Roulant, 2018-a)

### ***Demographics***

The community case study site is located in the Plateau Mont-Royal borough, which as of 2016 had a population of 104,000 people (Ville de Montreal, 2018-b). Encompassing a total of 8.1 km<sup>2</sup> the population density is 12,792.1/km<sup>2</sup> (Ville de Montreal, 2018-b). There are 56,730 private households with an average number of 1.8 people per residence, and the median annual income is \$30,243 (Ville de Montreal, 2018-b).

### ***Land Use***

The site is located in the Plateau-Mont-Royal borough of Montreal in a residential land use area. The surrounding area is culturally rich and predominately features residential and mixed use; with a few institutional, green spaces, and employment land uses scattered throughout the area (Fig. 8). From an architectural perspective, the City of Montreal recognizes much of the Plateau-Mont-Royal borough to have exceptional architectural value and built heritage.



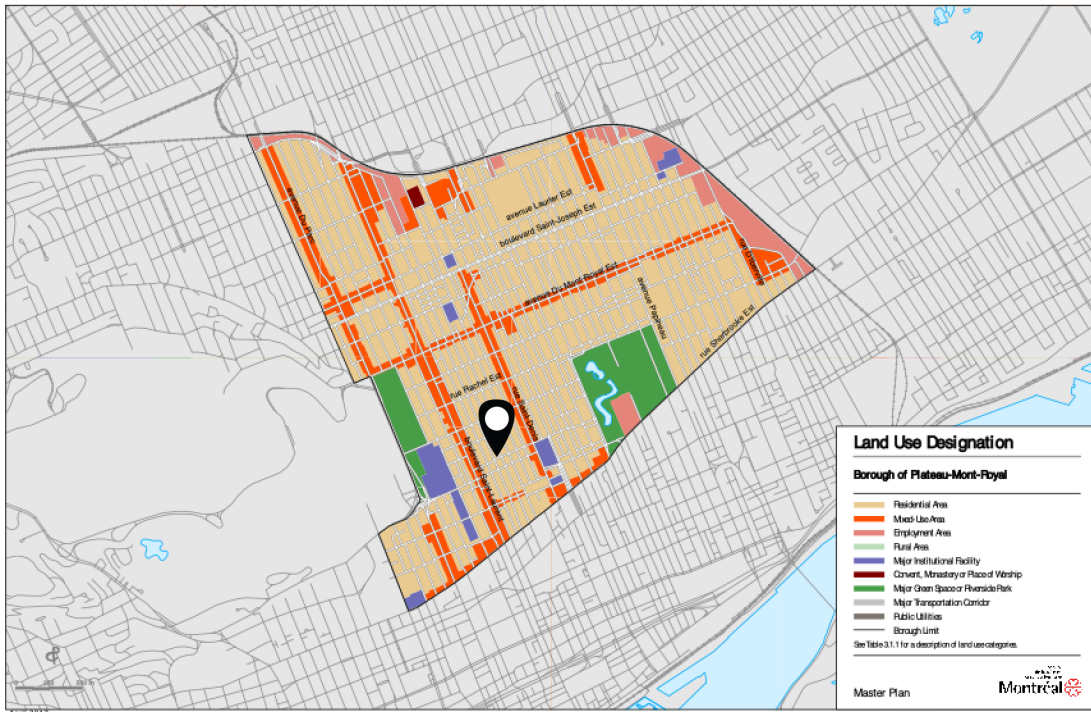


Figure 8: Community Case Study - Surrounding Land Uses in the Plateau-Mont-Royal Borough (Ville de Montreal, 2018-b, p. 39)

### *Climate*

Santropol Roulant's rooftop garden is not enclosed; therefore, it is exposed to the elements and only harvests produce from June to October (Santropol Roulant, 2018-a) (see more on Montreal's climate in Section 2.1).

### *Type of RA, Food Production and Recipients*

Santropol Roulant's garden uses an intensive rooftop, beehives, and 70 containers to grow over 115 varieties of vegetables, herbs, and edible blooms (Viau, 2018). In 2017, 400kg of vegetables were harvested from the urban gardens (combined total harvested from the Santropol Roulant rooftop garden and the McGill University garden), a financial value of \$5,000 CAD (Santropol Roulant, 2017). The harvested produce contributed to 23,024 meals in 2017 (averaging 88.6

meals/day) (Santropol Roulant, 2017). Some produce is also sold in the organization's urban farmers' markets (Fig. 9), CSA baskets, and general store (small boutique located in the Santropol Roulant office) (Santropol Roulant, n.d.).



*Figure 9: Community Case Study - Santropol Roulant's Urban Market (Santropol Roulant, 2017, p. 8)*

### ***Access to Rooftop***

Santropol Roulant's rooftop garden was visited by over 400 people in 2017, which does not include the numerous volunteers and staff attending to the garden during the warmer months (Santropol Roulant, 2017). The rooftop is accessible by elevator from the main floor of the building (Fig. 10), and is used to transport people, materials, and produce (Santropol Roulant, 2017).



*Figure 10: Community Case Study - Santropol Roulant's Elevator Access (Santropol Roulant, 2017, p. 4)*

### ***Site Dimensions***

Santropol Roulant's rooftop garden is approximately 1400 sq. ft., which includes the intensive garden (Fig. 11), container gardens, and beehives (Viau, 2018).



Figure 11: Community Case Study - Santropol Roulant's Intensive Garden (Santropol Roulant, n.d.)

### **Revenue Sources**

As a not-for-profit organization, Santropol Roulant relies heavily on outside funding sources; however, they have also developed a few of their own business ventures to gain additional income, such as renting their second-floor space for events or meetings. Revenue sources include events (2%), collectives (3%), social entrepreneurship (3%), corporate gifts (5%), amortization (7%), individual donations (14%), programs such as meals-on-wheels and UA (19%), government grants (22%), and donations from public and private foundations (25%) (Santropol Roulant, 2017).

### **Planning Context**

Along with the *City of Montreal's Master Plan*, the Plateau Mont-Royal borough has established a *Sustainable Development Action Plan* that helps guide development in the area.

The *Sustainable Development Action Plan 2016-2020* identifies goals specific to the area, including: reduction of GHG emissions and fossil fuels; greening, increasing biodiversity and ensuring the sustainability of resources; ensuring access to sustainable neighbourhoods on a human scale and in health; making the transition to a green, circular, and accountable economy; and mobilizing stakeholders (Le Plateau-Mont-Royal, 2016). Actions outlined in the Plan strive to protect and enrich biodiversity and integrate UA and healthy lifestyles more fully into the community's identity by developing an inventory and maintaining and strengthening the projects currently in operation (Le Plateau-Mont-Royal, 2016).

### **Regulatory Context**

The Plateau Mont Royal borough's by-law has two main sections that directly influence the ability to implement rooftop gardens in the borough: rules relating to the height of buildings and open space requirements for buildings that were built after the year 1994.

Firstly, Section III Subsection 21 mentions that a stairwell or an elevator shaft may exceed the roof or the maximum prescribed heights, as long as the construction has a setback of at least twice its height from the front façade (e.g. if an elevator shaft is 10 feet tall, the minimum setback required is 20 feet) (Ville de Montreal, 2001-b). As we see in the example of Santropol Roulant's rooftop, visitors access the garden by elevator. The elevator shaft exceeds the height of the roof; therefore, it is set back from the front of the building façade by at least twice the elevator's height.

The Bylaw also requires buildings built after the year 1994 that cover more than 85% of the property area to have open spaces (Ville de Montreal, 2001-b). The amount of open space required must be at least 10% of the total floor area of every dwelling unit, up to a maximum of 10 m<sup>2</sup> (108 ft<sup>2</sup>) per dwelling unit (Ville de Montreal, 2001-b). This required open space may be

provided in the form of a lot, balcony, terrace, an interior public space, or a garden that is accessible to the residents (Ville de Montreal, 2001-b).

Section VIII-Subsection I, states that “Commercial Greenhouses or Nurseries are an authorized use in Category C.6(1)” (Ville de Montreal, 2001-b, p. 49) and community gardens are authorized in Public Spaces and Places, Category E.1(1) (Ville de Montreal, 2001-b, p. 63).

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### 6.1.3 Commercial

**Name of Organization:** Lufa Farms

**Goal:** To produce high yields of fresh ingredients and to reconnect people with where their food comes from right in the city limits (Lufa Farms, 2018).

**Address:** 1400 Rue Antonio Barbeau, Montréal, QC

**Borough:** Ahuntsic-Cartierville

**Zone:** 0339

**Land Use Designation:** I.4A (Industrial)

**Building Height:** The allowable building height in this zone is 7-23m. The height of the host building is 2 storeys or approximately 8 m.



*Figure 12: Commercial Case Study - Lufa Farms Ahuntsic Location Rooftop Garden (Lufa Farms, 2018, p. 9).*

### ***Site Introduction***

Lufa Farms represents the commercial case study. Founded in 2011 by Mohamed Hage and Lauren Rathmell, Lufa Farms currently employs 140 people in Montreal (Lufa Farms, 2018). The Lufa Farms Ahuntsic location was the world's first commercial rooftop garden (Fig. 12), and the company now has three throughout Montreal with plans to expand elsewhere (Lufa Farms, 2018). This case study specifically focuses on Lufa Farms' first rooftop; however, it will also address certain aspects of the two newer rooftops, as there have been advancements made over the years. The host building (where the greenhouse is located on the roof) is a two-storey commercial building (Fig. 13).



*Figure 13: Private Case Study - Lufa Farms Ahuntsic Location Rooftop Garden Host Building in Montreal, Quebec. February 23, 2017.*

### ***Demographics***

The first Lufa Farms garden is located in the Ahuntsic-Cartierville borough. The Borough is the fifth largest by population in Montreal, with 134,425 people in 2016 over a total of 24.2 km<sup>2</sup> making the population density 5556.5/km<sup>2</sup> (Ville de Montreal, 2016-b). There are 59,015 private households with an average number of two people per residence, and the median annual income is \$29,062 (Ville de Montreal, 2016-b).

### ***Land Use***

The commercial case study is located in an employment area, predominately featuring residential, employment, and institutional land uses (Fig. 14) (Ville de Montreal, 2015).



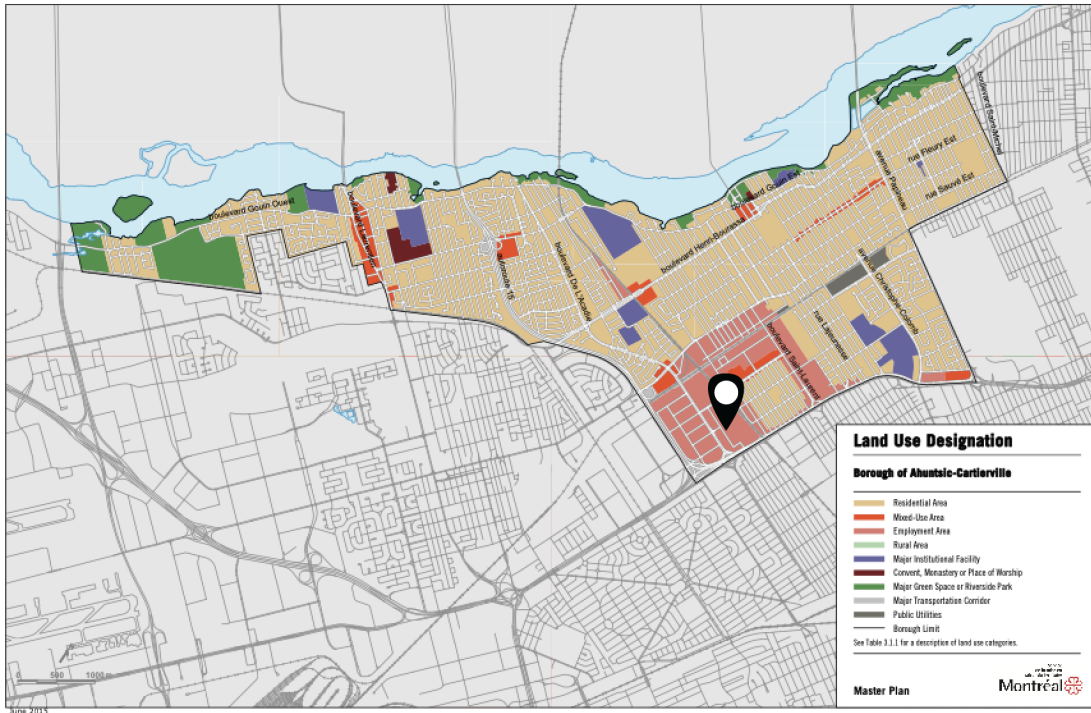


Figure 14: Commercial Case Study - Ahuntsic-Cartierville Borough Land Uses (Ville de Montreal, 2015, p. 39).

### ***Climate***

All Lufa Farms rooftop gardens are enclosed in a greenhouse and can therefore operate all year, regardless of climate. Being on a rooftop allows Lufa Farms to collect rainwater to hydrate the plants and any additional irrigation water is recirculated in a closed-loop system, reducing water consumption (Lufa Farms, n.d.-b). The greenhouse heats and cools certain areas, creating several “microclimates” to ensure the best growth environment for specific vegetables and herbs (Greenhouse Canada, 2012).

### ***Type of RA, Food Production and Recipients***

Using a hydroponic farming system, Lufa’s Ahuntsic location grows five varieties of tomatoes, two types of cucumbers, three different pepper varieties, eggplants, various herbs and lettuces, bok choy, kohlrabi, and chards, to name a few (Greenhouse Canada, 2012). Lufa delivers fresh food

from their three rooftop locations to 10,000 people each week, feeding about 2% of the populations in Greater Montreal, Trois-Rivières, and Quebec City (Lufa Farms, 2018). On average, Lufa Farms produces approximately 208,000kg of food each year which is sold in their online marketplace (Lufa Farms, 2018). Montrealer's are able to purchase fresh produce directly from the company website and either pick it up at one of the pick-up locations, or have it delivered to their homes.

### ***Access to Rooftop***

Once a week, Lufa Farms opens its doors to schools and organizations, and every few months the farm is open to the public (Lufa Farms, 2018). There is an elevator and loading dock on the south side of the building for transporting fresh produce and preparing them for daily deliveries using their electric cars (Fig. 15) (Lufa Farms, n.d.-c). The company also offers various pick-up points throughout Greater Montreal, Trois-Rivières, and Quebec City (Lufa Farms, 2018).



*Figure 15: Commercial Case Study - Lufa Farms Pick-and-Pack Program (Lufa Farms, n.d.-c)*

### ***Site Dimensions***

Lufa Farms' Ahuntsic rooftop grows vegetables and herbs in their greenhouse, which is a total of 32,000 sq. ft. of growing space (Lufa Farms, n.d.-b).

### ***Revenue Sources***

Lufa Farms revenue sources come from selling their agricultural produce. While the initial startup cost was high, at around \$2.2 million CAD, their maintenance costs are low compared to traditional ground-level farm, using about half the energy and only \$15 per day in fuel to deliver food throughout Montreal (Mandel, 2013). As of February 2018, Lufa Farms had received \$2.8 million in revenue, breaking even with the initial startup cost back in 2016 (City Lab, 2018).

### **Planning Context**

Along with the *City of Montreal's Master Plan*, the Ahuntsic-Cartierville Borough has established a *Climate Change Adaptation Plan* that helps guide development in the area.

The Plan describes the measures and commitments made by the Ahuntsic-Cartierville Borough to cope with the climatic events that are already affecting the area as well as those anticipated in the next few years. Some measures that relate to or may be mediated by RA include: protection of biodiversity; retain or recover rainwater; increase the resilience of infrastructure and buildings in the face of runoff water; minimize impervious surfaces; increase and preserve the vegetal cover; and counter heat islands (Ahuntsic-Cartierville Montreal, 2016, p. 17).

### **Regulatory Context**

Ahuntsic-Cartierville's by-law has two main sections that directly influence the ability to implement rooftop gardens in the borough: rules relating to the height of buildings and open space requirements for buildings that were built after the year 1994 (Ville de Montreal, 2001-c). Operating as a Commercial Greenhouse, the Lufa Farms building falls into the Commercial land use category C.6(1) (Ville de Montreal, 2001-c).

In the Ahuntsic-Cartierville borough, the height in storeys is "the number of storeys, including the ground floor, between the floor of the ground floor and the ceiling of the top storey, excluding a roof-top enclosure" (Ville de Montreal, 2001-c, p. 6). Section III states that "a stairwell or an elevator shaft may exceed the roof or the maximum prescribed heights in meters and in storeys by a setback in relation to the façade equivalent to at least twice its height" (Ville de Montreal, 2001-c, p. 7).

Section III states "a shelter allowing the use of a roof for relaxation or recreation purposes by the occupants of a building would be excluded from the total floor area ratio (FAR) calculations" (Ville de Montreal, 2001-c, p. 10). The Bylaw also requires buildings built after the year 1994 that cover more than 85% of the property area to have open spaces. The amount of open space required must be at least 10% of the total floor area of every dwelling unit, up to a maximum of 10 m<sup>2</sup> (108 ft<sup>2</sup>) per dwelling unit (Ville de Montreal, 2001-c). This required open space may be "provided in the form of a lot, balcony, terrace, an interior public space, or a garden that is accessible to the residents" (Ville de Montreal, 2001-c, p. 11).

#### **6.1.4 Summary**

Based on the site analyses above, some conclusions can be drawn regarding the characteristics of the various neighbourhoods and the types of RA typically found there.

The smaller-scale private and community projects are located in mixed-use or residential areas, meanwhile the commercial RA project is located in employment (often referred to as industrial) areas due to the sheer size required for operation.

The smaller-scale private and community projects have exposed gardens and only operate for a portion of the year during growing season (typically June-October), meanwhile the commercial RA projects is enclosed with a greenhouse so they can operate year-round to ensure they are able to provide a consistent yield.

Private and community rooftop gardens can operate at any scale, meanwhile the commercial rooftop gardens require a significant amount of square footage to be able to grow the amount of produce required to feed make a profit.

All scales of RA projects require elevators for access to transport tools, soil, and produce with ease. Rooftop gardens that operate for-profit tend to have more strict rules on who can access the rooftops. Both the private and commercial RA projects will occasionally allow visitors to access the roof on a guided tour. On the other hand, the community RA project, which is a not-for-profit organization, is regularly open to the public for viewing purposes.

	<b>Private</b> <i>Fairmont Hotel</i>	<b>Community</b> <i>Santropol Roulant</i>	<b>Commercial</b> <i>Lufa Farms</i>
<b>Borough</b>	Ville-Marie	Plateau-Mont-Royal	Ahuntsic-Cartierville
<b>Demographics</b>	<u>Population:</u> 89,170 <u>Borough Area:</u> 16.5 km <sup>2</sup> <u>Density:</u> 5397.7/km <sup>2</sup> <u>Median Annual Income:</u> \$25,486	<u>Population:</u> 104,000 <u>Borough Area:</u> 8.1 km <sup>2</sup> <u>Density:</u> 12,792.1/km <sup>2</sup> <u>Median Annual Income:</u> \$30,243	<u>Population:</u> 134,425 <u>Borough Area:</u> 24.2 km <sup>2</sup> <u>Density:</u> 5556.5/km <sup>2</sup> <u>Median Annual Income:</u> \$29,062
<b>Land Use</b>	Mixed-use	Residential	Industrial/Employment
<b>Climate</b>	Exposed garden – operates June-October	Exposed garden – operates June-October	Enclosed greenhouse – operates year-round
<b>Type of RA</b>	Raised Beds and Smart Pots	Intensive Rooftop, Beehives, and Containers	Hydroponics

<b>Rooftop Access</b>	Elevator – regular access only provided to staff	Elevator – open to the public for viewing purposes	Elevator – regular access only provided to staff. Once a week open to schools and organizations, every few months open to the public for viewing purposes
<b>Site Dimensions</b>	Less than 400 ft <sup>2</sup>	1400 ft <sup>2</sup>	32,000 ft <sup>2</sup>
<b>Food Produced (average/year)</b>	105kg	400kg	208,000kg
<b>Revenue Sources</b>	Operating costs come from Fairmont Hotel itself, some produce is sold in Hotel’s urban market for-profit	Relies heavily on outside funding sources	Revenue generated from produce sales
<b>Planning Context</b>	Master Plan, Sustainable Development Action Plan, Food Strategy Action Plan	Master Plan, Sustainable Development Action Plan	Master Plan, Climate Change Adaptation Plan
<b>Regulatory Context</b>	Ville-Marie By-Law	Plateau-Mont-Royal By-Law	Ahuntsic-Cartierville By-Law

Table 8: Summary of Site Analyses

## 6.2 Methods of Rooftop Agriculture

Each of the case studies use different methods for growing food on their rooftops. The types of RA methods discussed in more detail below include raised beds, intensive roof gardens, containers, beehives, and hydroponics.

The private case study at the Fairmont Hotel rooftop garden uses raised beds and smart pots (a form of a container) for vegetable, herb and edible flower production, and beehives for honey production. Santropol Roulant, or the community case study, uses an intensive rooftop garden (also referred to as row gardens), containers, and beehives. And lastly, the commercial case study, Lufa Farms, uses hydroponics for vegetable and herb production.

### 6.2.1 Raised Beds

The Fairmont Hotel, or the private case study rooftop garden, uses raised beds for vegetable, herb and edible flower production. Raised beds are pre-fabricated boxes that can be filled with

soil and typically provide more growing space than containers, with dimensions often ranging from 6 to 8 inches high, 3 to 6 feet wide and 6 to 8 feet long (Berle & Westerfield, 2013). Raised beds are a good option for a rooftop that is looking for a simple and inexpensive installation; however, the raised beds tend to be more permanent than container gardens and weigh less than intensive rooftop gardens (Mandel, 2013). If weight is an issue for a rooftop, it's recommended that the raised beds are constructed using lightweight materials, such as wood or metal siding and are spread out on the roof to distribute their weight proportionately (Mandel, 2013).

Advantages	Disadvantages
Simple, attractive, low initial cost	Limited production area
Good soil drainage	Susceptible to temperature fluctuations
Higher yields than containers	Occasional frame maintenance / cost of construction and repairs
Soil gains heat more quickly than row farming	Weighs more than containers
Extended growing season (during spring)	

*Table 9: Advantages and Disadvantages of Raised Beds on Rooftops (Based on data from Mandel, 2013).*



*Figure 16: Raised Beds on the Private Case Study's Rooftop Garden (Image provided by Papineau, 2018).*

## 6.2.2 Containers

Containers are likely the simplest method for food production. Most small-scale gardeners choose to grow their produce in containers, as they are relatively low in cost, require minimal planning (you can buy one at most of your local hardware or plant shops), they can be placed in most locations on the rooftop since they do not weigh very much, can be moved easily with the change of seasons, and they come in a variety of sizes and materials.

Rooftop container gardening is similar to containers being used on the ground; although, rooftop gardeners need to be more mindful about high winds. Containers can easily be blown over, which could be dangerous given they are on a rooftop. Some gardeners avoid this by placing their containers against a wall or next to something that shields the wind (Mandel, 2013).



Advantages	Disadvantages
Flexible weight distribution (mobile)	Plant vulnerability (not enclosed)
Inexpensive	Soil loses heat quickly
Easy-to-use	Lower yields than other methods
Minor weeding required (less staff necessary)	

Table 10: Advantages and Disadvantages of Containers on Rooftops (Based on data from Mandel, 2013).



Figure 17: Container Gardens on the Community Case Study's Rooftop Garden (Santropol Roulant, 2018-b)

### 6.2.3 Intensive Roof Gardens

Santropol Roulant, or the community case study, also uses an intensive rooftop garden, which is sometimes referred to as “row farming, or linear crop production in contiguous beds” (Mandel, 2013, p. 42). These types of gardens are ideal for large-scale production and can support almost any type of crop, although require a higher initial investment and a rooftop with a high structural capacity to hold the heavy weight (Mandel, 2013).



Figure 18: Intensive Garden on the Community Case Study's Rooftop (Santropol Roulant, n.d.).

Advantages	Disadvantages
Support almost any type of crop	Heavy weight / requires intense structural support
Unobstructed flow of water (all one bed)	More difficult to maintain
Potential for large-scale production	Higher start-up costs

Table 11: Advantages and Disadvantages of Intensive Gardens on Rooftops (Based on data from Mandel, 2013).

#### 6.2.4 Hydroponics

Lufa Farms, or the commercial case study, uses hydroponics in a greenhouse for their vegetable and herb production. Hydroponics are a good option for high-yield production in a limited amount of space and without soil (Mandel, 2013). By using the hydroponics system, Lufa Farms is able to grow 10 to 15 times more vegetables and herbs than a standard ground-level farm (see Section 6.3 for yield) (Mandel, 2013). Hydroponics are an efficient use of space and the use of a greenhouse provides an extended growing season; however, the initial cost for creating a

hydroponic farm is high, they require regular maintenance, and they require highly skilled training and labour (Mandel, 2013).

Advantages	Disadvantages
High yields	High initial investment
Lightweight	Lengthy construction period
Efficient use of space	Regular maintenance required
Extended growing season and off-season harvesting (greenhouse)	Energy intensive
Creates highly skilled jobs	Requires highly skilled labour

Table 12: Advantages and Disadvantages of Hydroponics on Rooftops (Based on data from Mandel, 2013).



Figure 19: Lufa Farms Hydroponic System (Lufa Farms, n.d.-d)

### 6.2.5 Beehives

Both of the open-air (not enclosed in a greenhouse) rooftop garden case studies, the private and community, rely heavily on beekeeping not only for honey production but for pollination. Mandel (2013) states that “the most necessary farm animal of all is the honeybee” (p.66). Many rooftop farms realize the benefits of playing host to beehives and their honeycombs. In fact, honeybees that live in cities “are generally healthier and more productive than rural bees” (Mandel, 2013, p. 66).

Advantages	Disadvantages
Pollination of crops (service)	Some communities are against urban beekeeping because they believe bees are a nuisance / dangerous
Honey (product)	Regular maintenance required
Low start-up cost	Requires high level of knowledge and skill

Table 13: Advantages and Disadvantages of Beehives on Rooftops (Based on data from Mandel, 2013).

### 6.2.6 Summary

Raised beds, intensive roof gardens, containers, beehives, and hydroponics all offer a wide variety of food production options for rooftops based on available space, budget, climate/growing season, and the amount of food production (yield) required.

## 6.3 Food Items Being Grown

RA Case Study Site	Size (growing space)	Annual Yield (amount of food grown)	Growing Method	Growing Season	Crops Being Grown
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<b>Private</b> Fairmont Hotel Queen Elizabeth	400 ft <sup>2</sup>	105.65kg (on average)	Five 4' x 8' raised beds, six smart pots, beehives	Seasonal (typically Spring-Fall)	Herbs, edible blooms, cucumbers, melons, peppers, spinach, kale, honey
<b>Community</b> Santropol Roulant	1,400 ft <sup>2</sup>	400kg	Intensive rooftop, 70 containers, beehives	Seasonal (typically Spring-Fall)	115 varieties of vegetables, herbs, edible blooms, honey
<b>Commercial</b> Lufa Farms	32,000 ft <sup>2</sup>	208,000kg	Hydroponics	Year-round (Greenhouse)	Five varieties of tomatoes, two types of cucumbers, three different pepper varieties, eggplants, various herbs, 50 varieties of lettuces, bok choy, kohlrabi, and chards

Table 14: Growing Statistics at Case Study Sites

### 6.3.1 Summary

Each case study site grows a wide variety of produce. The growing season, type of crop and size of yield are dependent on the method of production (container, raised beds, intensive rooftop, or hydroponic) and the type of rooftop garden (open-air or greenhouse).

## 6.4 Barriers to Creating a Rooftop Garden in Montreal

While Montreal has managed to develop a number of successful rooftop gardens throughout the City, there remain several barriers and constraints which may make the initiation and maintenance of a rooftop garden more difficult, including cost, technical/horticultural, climate, and administrative barriers. The barriers described below have been drawn from various literature not just specific to Montreal, but for any rooftop garden in a similar climate.

### 6.4.1 Cost

As discussed in Section 6.5, RA methods vary in start-up and maintenance costs. While raised beds, containers, and beehives are known to have low initial start-up costs, other methods such as intensive roof gardens and hydroponics may not be financially feasible for many individuals or organizations. Additionally, many roofs are not structurally capable of supporting the weight of a rooftop garden and retrofitting a roof can be extremely costly. There are many other factors that can increase the cost of installing and maintaining a rooftop garden (depending on the type and scale) including providing access to the rooftop by way of a staircase or elevator, general maintenance costs such as new soil and tools, and paying wages to garden staff.

The City of Montreal has made significant efforts in recent years related to the environment and sustainable development (such as the *Climate Change Action Plan 2015-2020* and *Sustainable Montreal 2016-2020* to name a few). With the recent implementation of these plans, some funding has been made available to support projects related to achieving the City's goals as outlined in the action plans. For example, the City unveiled two programs totaling \$118.6 million: the first program provides funding for the rehabilitation of contaminated lands, and the second program provides funding for sustainable industrial buildings (Ville de Montreal, n.d.-c). While these programs provide financial support for certain projects and can increase the

feasibility of developing a rooftop garden in Montreal, the requirements are specific and limit the individuals and organizations that may benefit from this funding.

#### **6.4.2 Technical / Horticultural**

The technical and horticultural barriers that appeared in the site analysis section and literature review include access to the rooftop, structural capacity for the additional weight of a garden, available production areas, and yield capacity.

Access to rooftops vary depending on building code requirements and whether it is a private or publicly accessible garden. Most local building codes will prescribe how rooftops can be accessed, and the setback requirements of structures (such as elevators) on the rooftop. Access to rooftops require either a staircase or an elevator. Stairs would not be accessible for individuals with restricted mobility and they are also not ideal for transporting heavy materials and large amounts of produce. Elevators are used in all three of the case study sites and are an ideal and more efficient means of accessing and transporting goods to and from the rooftops. Freight elevators are preferable to private or public elevators, as transporting soil and produce can cause a mess. Both elevators and stairs require additional space in the building and can be quite expensive.

The required structural capacity of a rooftop varies depending on the type of RA practice (e.g., containers, raised beds, intensive, or hydroponics). Each type has different soil and material requirements that differ in weight: containers being the most flexible weight distribution, hydroponics being lightweight, and raised beds or intensive gardens being the heaviest. A structural engineer must assess the feasibility of a rooftop to support the weight of a garden, also referred to as a roof's load capacity. If an engineer determines that the rooftop is not structurally capable of supporting an intensive or raised bed garden, containers may be an option. If the

rooftop is unable to support any additional weight, it may be possible to reinforce the roof; however, this is typically a very costly endeavor.

As buildings come in various shapes and sizes, rooftops can sometimes have limited production areas. The amount of space available on a rooftop can dictate the type of agriculture possible. For example, containers require the least amount of space and can be moved relatively easily and on the other hand, methods such as raised beds, intensive roof gardens, and hydroponics require significantly more space. The production area also influences the roof's yield capacity. Depending on the amount of space available and the type of agriculture being used the rooftop may be limited in how much food it can produce.

#### **6.4.6 Climate**

The climate can be a significant barrier to growing food on rooftops. If the garden is exposed (not in a greenhouse) the growing period is limited from spring to fall and even within this time period it relies heavily on the appropriate amount of heat, sun, wind, and moisture. High winds cause soil loss and drying, while temperature fluctuations cause drying, freezing, or premature flowering. Selecting a site such as a shorter building that is surrounded by taller adjacent buildings will help minimize the garden's exposure to wind and too much sun. Temperature fluctuations can be reduced by providing additional shade not available by neighbouring buildings in the form of shade cloth. Shade cloth can be draped over gardens to protect them from the sun and in turn keep the garden cool.



#### **6.4.7 Administrative**

Depending on the scale of the project, administrative barriers to growing a rooftop garden may include staffing, marketing, and profitability.

Developing and maintaining a successful rooftop garden requires a knowledgeable gardener, and oftentimes more than one. It takes time and resources to hire, train, and pay garden staff. Depending on the type of project, some gardens require staff to lead workshops, organize events and media inquiries, and coordinate volunteers on top of their typical gardening duties.

For many gardens, effective marketing is a powerful tool. Private gardens can occasionally benefit from marketing. For example, the Fairmont Hotel uses vegetable and herbs from their rooftop garden and markets this on their website and in their restaurants. For not-for-profit and commercial gardens marketing is especially important. Not-for-profit organizations rely on marketing to spread the word to the general public about the services they provide, as well as to prospective funders. Larger, commercial rooftop gardens rely on creative marketing to sell their produce. Lufa Farms has developed an online shopping platform where people can purchase their produce, and have it delivered by a company-branded electric vehicle or bicycle. Some rooftops also share their stories by allowing people to visit their rooftops, which can be a powerful way to spread the word about the organization. Media is also an effective way to market a rooftop garden. Often, not-for-profit or commercial rooftop gardens will share their stories with a large audience by way of print or broadcast media.

### **6.5 Municipal Policy Context**

The City of Montreal has a number of plans and policies that are used to set a vision for future development and guide goals and actions. The following categories are explored to gain a better

understanding of Montreal's policy context and how they relate to RA: environment and sustainable development, food security, and UA.

### 6.5.1 Environmental and Sustainable Development Policy Context

There are currently no policies specifically for RA in Montreal; however, there are other policies that are related to their development, including: *Sustainable Montreal 2016-2020*, *Climate Change Action Plan for the Montreal Urban Agglomeration 2015-2020*, and the *Montreal Master Plan*.

*Sustainable Montreal 2016-2020* presents challenges and priorities to make Montreal a more sustainable city. The plan establishes four sustainable development priorities, three of which relate to RA. The first is to “add vegetation, biodiversity, and the continuity of resources” (Ville de Montreal, 2016-a, p. 13). In response to this priority, Action 5 states “increase plantings in the built environment” (Ville de Montreal, 2016-a, p. 21). In order to do this, the City plans to double the number of green roofs on municipal buildings from 11 to 22 by 2020 (Ville de Montreal, 2016-a, p. 21). The second priority is to “reduce GHG emissions and dependence on fossil fuels” (Ville de Montreal, 2016-a, p. 18). In response to this priority, Action 3 states “build and/or renovate buildings sustainably, by meeting or targeting recognized certification criteria, improving energy efficiency and eliminating, where applicable, heating oil as energy source (Ville de Montreal, 2016-a, p. 18). Buildings with green roofs qualify to receive additional LEED sustainability points and help to reduce energy consumption by insulating the building in the cooler months and protecting the building from direct solar heat in the warmer months. The third priority is to “ensure access to sustainable, human-scale and healthy neighbourhoods” (Ville de Montreal, 2016-a, p. 13). In response to this priority, Action 12 states to “make UA and healthy lifestyles habits part of the DNA of neighbourhoods” (Ville de Montreal, 2016-a, p. 23). The City

plans to do this by devoting nearly \$1 million to funding community organizations that promote healthy eating and physical activity, and by developing a municipal food policy (Ville de Montreal, 2016-a, p. 23).

The *Climate Change Action Plan for the Montreal Urban Agglomeration 2015-2020* outlines the climate hazards for the City, adaptation challenges, and adaptation measures. The climate hazards addressed include: higher average temperatures, heavy rainfalls, heat waves, destructive storms, drought, and river floods (City of Montreal, 2017, p. 30). Of the 24 adaptation measures, 6 relate to RA: protect biodiversity, harvest rainwater, increase buildings' resilience to runoff water, increase and preserve tree and plant cover, mitigate heat islands, and provide spaces for people to cool off and avoid exposure to oppressive heat (City of Montreal, 2017, p. 30).

The City's Master Plan identifies various planning goals and actions for improving life in Montreal. The first planning goal that relates to RA is creating "high quality, diversified and complete living environments" (City of Montreal, 2005, p. 11). In response to this planning goal, the Master Plan encourages the design of "public and private green spaces that enrich living environments" as an action (City of Montreal, 2005, p. 19). The second planning goal that relates to UA is more "high quality architecture and urban landscapes" (City of Montreal, 2005, p. 113). In response to this planning goal, the Master Plan identifies preserving and enhancing "rural character and agricultural areas of the West Island" as an action (City of Montreal, 2005, p. 127). The third planning goal that relates to RA is "a healthy environment" (City of Montreal, 2005, p. 171). In response to this planning goal is the action to "ensure the optimal management of resources in an urban context" (City of Montreal, 2005, p. 173). The City of Montreal "supports measures to ensure healthier urban development by reducing paved areas and decreasing the impact of heat islands" (City of Montreal, 2005, p. 173). The formation of heat islands is a result

of too many hard surfaces such as parking lots, roads, and buildings in one area. RA can help to reduce heat islands by providing vegetation, which absorbs heat. The Master Plan specifically mentions integrating more green roofs on “commercial, industrial, institutional and municipal buildings” for heat absorption, but also for the absorption of pollutants and rainwater (City of Montreal, 2005, pp. 174,175).

### 6.5.2 Food Security Policy Context

The City of Montreal has one primary document which influences food security: *Système Alimentaire Montréalais (SAM) 2025*, meaning Montreal’s Food System in English. SAM is an arms-length organization of the City of Montreal.

SAM 2025 has developed a comprehensive food development plan with a long-term vision structured around 5 overarching goals, 14 areas of intervention, and approximately 30 collective objectives achievable on both a regional and local level. The goal of the plan is the by 2025, all citizens of Montreal will have access to healthy, diverse, local and affordable food (Système Alimentaire Montréalais, 2014). The five goals of SAM 2025 include: increasing and diversifying the local food supply; reducing the ecological footprint of the food system; promoting access to healthy eating; and strengthening the community (Système Alimentaire Montréalais, 2014). The first action for implementing these goals that relates to RA includes the preservation of land, diversification of food production, and increases support for projects that focus on innovation and distribution to various groups and needs (Système Alimentaire Montréalais, 2014, p. 6). The second action related to RA includes promoting new urban projects that integrate food spaces (Système Alimentaire Montréalais, 2014, p. 7). The third action that relates to RA supports food production initiatives that respect good environmental practices and contribute to the preservation of biodiversity in urban spaces (Système Alimentaire Montréalais, 2014, p. 7).

### 6.5.3 Urban Agriculture Policy Context

While there is no official policy directing RA or UA in Montreal, the City has developed a guide for creating and managing an at-grade community garden: *Creer un Jardin Communautaire* (Pedneault & Grenier, 1996). While the document is quite dated being over 20 years old, it describes the evolution of Montreal's community garden program and contains useful information about financial management and funding; integration into community life; horticultural techniques (including plant suggestions); and specialized gardens for children or people with reduced mobility (Pedneault & Grenier, 1996). Although this guide is made for at-grade community gardens, some of the resources can also be useful for developing a RA project.

Montreal's community gardens are managed by their respective borough, and each garden elects a volunteer committee to oversee its operations (Ville de Montreal, n.d-a). There are 18 boroughs which provide land, soil, a water source, a tool shed or toolbox, tables, fences, sand, paint and flowers (Ville de Montreal, n.d-a.).

### 6.5.4 Summary

Policies supporting urban and RA in Montreal are a good way to guide development and achieve the City's goals. Montreal offers comprehensive policies pertaining to the environment and sustainable development, such as *Sustainable Montreal 2016-2020*, the *Climate Change Action Plan for the Montreal Urban Agglomeration 2015-2020*, and the Montreal Master Plan which also promote the improvement of urban environmental conditions and site the integration of more greenspace as a strategy. The City has also recently integrated a policy for increased food security: *Système Alimentaire Montréalais (SAM) 2025*. The policy has a desire to improve Montreal's food system and mentions the integration of more UA as a solution for increasing

access to affordable and healthy food. While Montreal has a long history of UA, the policy context specifically for UA is lacking. The City's official website offers a guide for creating and managing an at-grade community garden: *Creer un Jardin Communautaire*. While this guide contains useful information, it is over 20 years old and is therefore quite outdated. The City of Montreal sees the value in integrating agriculture into the urban environment and is on its way to developing a good set of policies that support urban and RA initiatives.

## **6.6 Summary of Findings**

A comparative case study of three RA projects in Montreal has revealed various RA practices and scales can be implemented and successful in an urban area. The type of these projects varies: not-for-profit, private, and commercial. Based on the research findings, five common methods of agricultural production appropriate for use on roofs were identified: containers, raised beds, intensive roof gardens, beehives, and hydroponics.

After a review of these three case study sites, it seems that the current state of RA in Montreal is not as successful as it could be. More incentives are needed in Montreal before RA can become more popular. Some of Montreal's policies do acknowledge and encourage RA; however, there is more the City could do to encourage projects and more food production in the city limits in general.

### **6.6.1 Addressing the Research Questions**

The following section addresses the research questions posed at the beginning of the practicum, using data collected from two interviews, site analysis, and document analysis from the comparative case study.

### ***1. What are the different types and characteristics of rooftop agriculture?***

Based on the research findings, five common RA methods were identified with different characteristics: containers, raised beds, intensive rooftops, beehives, and hydroponics.

Container gardens are a simple and popular method for food production, partly due to the fact that they are relatively low in cost, require minimal planning (you can find a container in your backyard or buy one at most of your local hardware or plant shops), and they can be placed in most locations on the rooftop since they are relatively lightweight.

Raised beds are inexpensive, prefabricated boxes that are able to provide more growing space than containers. The frame required for raised beds increases the weight on the roof and occasionally requires maintenance.

Intensive rooftops have high yields making them ideal for large-scale production, they have the ability to support almost any type of crop and have an unobstructed flow of water since it remains all one bed. Some disadvantages include high initial costs, heavy weight, and as a result the requirement of intense structural support.

Beehives are desirable for some RA because the bees provide pollination of crops, production of honey, and have a relatively low start-up cost. Some RA finds that beehives can receive a negative reputation because some people find them a nuisance in the city, there is regular maintenance required, and beekeeping requires a high level of knowledge and skill.

Lastly, hydroponic RA is a good option for high-yield production in a limited amount of space and does not require soil, making it lightweight. Some disadvantages include a high initial investment, a lengthy construction period, regular maintenance, energy intensive, and requires highly skilled laborers.

## **2. What are the benefits of growing food on rooftops? How do they differ by type?**

### *2a) What are the community-level benefits of rooftop agriculture?*

The community-level benefits to growing food on rooftops include but are not limited to the environment, physical and social health, the local economy, and food security.

The main environmental community-level benefits of RA include stormwater management, the reduction of the urban heat island (UHI) effect, and the integration of patchwork ecosystems that can provide a temporary habitat for a variety of species such as birds, butterflies, and insects that may otherwise be pushed out of cities from overdevelopment and reduction of green spaces. These benefits are not specific to RA but are applicable to all green roofs. The simple fact of growing vegetation, which does not need to be edible, on rooftops can provide environmental community-level benefits.

RA can improve physical health by encouraging community members to spend time outdoors and gain exercise through gardening. There are many social health benefits related to RA, including the strengthening of family and community bonds by providing the community with the collaborative and shared activity of maintaining and harvesting produce. RA also has the ability of increasing a community's understanding of food production.

The local economy may also benefit from RA. RA provides access to jobs and may in some instances reduce the cost of groceries when food travels a shorter distance, or when people grow their own produce. The commercial case study, Lufa Farms, is an example of a RA project that may provide access to jobs; however, because it operates as a for-profit business, the produce grown and sold by Lufa Farms is not necessarily more affordable and consumers may not see a reduced cost of produce even though it is grown within the city limits. The private case study, the Fairmont Queen Elizabeth Hotel, does not benefit the local economy. The garden at the Fairmont is run by the restaurant's chefs, therefore no additional jobs are created for the maintenance of



the garden. Additionally, by growing their own vegetables, herbs, and edible flowers, the Fairmont Hotel reduces their own operational costs, but it does not benefit the general public or reduce grocery costs for Montreal residents. The not-for-profit case study, Santropol Roulant, has a few staff that help operate the garden, but the majority of the maintenance staff are volunteers, so the organization does not significantly improve access to jobs. As a not-for-profit organization, Santropol Roulant is able to sell their produce for a low cost (compared to conventional grocery stores), making it affordable for more Montreal residents.

From this comparative case study, it is unclear whether RA has the potential to eliminate cases of poverty and hunger or significantly improve local food security. As discussed previously, Lufa Farms' produce is not necessarily more affordable than traditional grocery stores, making the produce unattainable for individuals with low incomes. The Fairmont Hotel's produce is not for sale to the general public as it is only served in their luxury restaurants. The restaurants are expensive and would not benefit the general public. The only case study which improves local food security is Santropol Roulant. As a not-for-profit organization, they either donate produce to Montreal residents in need or sell it for a low cost to the general public. Due to the organization's small operating budget, short growing season, and limited growing space, Santropol Roulant is only able to reach a small proportion of the Montreal population. Therefore, it is not significantly improving food security in the City. If there were many organizations similar to Santropol Roulant that had more growing space and an extended growing season, perhaps it would be more evident whether RA could significantly improve local food security in Montreal.

*2b) How much food is produced, how is this measured, and who gets it?*

The amount of food produced varies greatly between each of the case study sites, depending on the type of RA used (containers, raised beds, intensive rooftops, beehives, and hydroponics) and

also on the project's respective goals. Each of the case study sites simply weighs the vegetables or herbs at each harvest and submits the number for general reporting.

The private RA, for example, has the goal to produce only enough food to serve in the Fairmont Queen Elizabeth Hotel's restaurants and to sell honey in the gift shop. Therefore, the hotel has a relatively small 400 square feet of growing space, uses containers and raised beds, has a short growing season, and produces relatively low annual yields of 105.65kg (on average). In 2016-2017, the Hotel underwent a major renovation and experienced some changes to their rooftop garden, so the garden did not produce vegetables during those two years and the yield was smaller in 2018 as they got set up with their new garden system.

The community RA, Santropol Roulant, is a not-for-profit organization that has the goal to produce as much food as possible during their growing season to create meals for Montrealers-in-need. In 2017, the organization produced 400kg of fresh produce, contributing to about 23,024 meals (averaging 88.6 meals/day) (Santropol Roulant, 2017). Some produce is also sold in the organization's urban farmers' markets, CSA baskets, and general store to offset the costs of maintaining the gardens.

The commercial RA, Lufa Farms, has the highest yields of the three case study sites as it operates a hydroponic system within a greenhouse, enabling the company to grow efficiently year-round. On average, Lufa Farms produces approximately 208,000kg of food each year which is sold in their online marketplace (Lufa Farms, 2018). Montrealers are able to purchase fresh produce directly from the website and either pick it up at one of the pick-up locations or have it delivered to their homes. Lufa Farms operates as a for-profit business and the produce is not necessarily affordable to all Montreal residents, significantly limiting who gets to benefit from their locally grown food.

*2c) What are the goals of these cases, and are they able to achieve these goals?*

The Fairmont Queen Elizabeth is privately-operated and only uses their produce to serve in the hotel's restaurants. Since developing their rooftop garden, the Hotel runs a relatively small garden and has been able to achieve their goal of producing fresh vegetables, herbs, and edible blooms to serve in their restaurants, which reduces their overall food costs.

Santropol Roulant, on the other hand, is a not-for-profit organization that grows, prepares, and distributes food. The organization has the goal of "increasing local food security, community development, and social inclusion" (Santropol Roulant, n.d.). Santropol Roulant strives to include as many members of the community as possible, with diverse volunteer opportunities and programming. They also put forward a serious effort to reach their goals and in 2017, the organization improved general accessibility to their services: they improved physical access to their rooftop by building an elevator and they made for-sale produce more accessible to people with varying budget requirements.

Lufa Farms has the goal to produce high yields of fresh ingredients to sell throughout Montreal. They strive to "reconnect people with where their food comes from right in the city limits" (Lufa Farms, 2018). As the largest rooftop garden in Montreal, Lufa Farms is able to achieve their goal of growing food in the city limits by growing fresh produce on their rooftops and selling it through their online marketplace. Lufa also offers regular tours of their rooftop garden in an effort to reconnect people with where and how their food is being grown.

***What are the most significant factors in creating a rooftop garden in Montreal, QC?***

*3a) What are the barriers or constraints related to process, i.e.: cost, planning, policy, structural, and others? and, 3b) How do these barriers or constraints vary between different types of rooftop agriculture?*

There are several barriers and constraints which may make the development and maintenance of a rooftop garden in Montreal more difficult, including cost, technical/horticultural, climate, and administrative barriers.

RA methods vary in start-up and maintenance costs. While raised beds, containers, and beehives are known to have low initial start-up costs, other methods such as intensive roof gardens and hydroponics may not be financially feasible for many individuals or organizations. Additionally, many roofs are not structurally capable of supporting the weight of a rooftop garden and retrofitting a roof can be extremely costly. There are many other factors that can increase the cost of installing and maintaining a rooftop garden (depending on the type and scale) including providing access to the rooftop, general maintenance costs, and employee wages. Some City funding has been made available that could benefit RA projects; however, the requirements are specific and could limit the individuals and organizations that may benefit from this funding. For example, the City is devoting nearly \$1 million per year to funding community organizations that promote healthy eating and physical activity (Ville de Montreal, 2016-a, p. 23). This type of funding may benefit an organization like Santropol Roulant but would not benefit individuals who would like to develop their own rooftop garden, or commercial or private organizations like Lufa Farms or the Fairmont Hotel.

The technical and horticultural barriers to RA include access to the rooftop, structural capacity for the additional weight of a garden, available production areas, and yield capacity. Access to rooftops vary depending on building code requirements and whether it is a private or publicly accessible garden. All three case study sites provide elevators for staff and visitors to access the rooftop and for the transportation of materials; however, some rooftop gardens of smaller scales or with limited budgets may not have elevators. Rooftops without an elevator pose barriers for people with reduced mobility and may present challenges when transporting

materials or produce to and from the rooftop. The structural capacity of a rooftop varies depending on the type of RA practice (e.g. containers, raised beds, intensive, beehives, or hydroponics). Each type has different soil and material requirements that differ in weight: beehives and containers being the most flexible weight distribution, hydroponics with lightweight infrastructure but heavy water requirements, and raised beds or intensive gardens being the heaviest overall. As buildings come in various shapes and sizes, rooftops can sometimes have limited production areas. The amount of space available on a rooftop can dictate the type of agriculture possible. The production area also influences the roof's yield capacity. Depending on the amount of space available and the type of agriculture being used, the rooftop may be limited in how much food it can produce.

The climate can be a significant barrier to growing food on rooftops, especially in winter cities. If the garden is exposed (not in a greenhouse), such as it is with Santropol Roulant and the Fairmont Hotel, the growing period is limited from spring to fall and even within this time period it relies heavily on the appropriate amount of heat, sun, wind, and moisture. Lufa Farms has successfully avoided the climatic barriers by enclosing their garden within a temperature controlled year-round greenhouse.

Depending on the scale and goals of the project, administrative barriers to growing a rooftop garden may include staffing and marketing. For example, the not-for-profit case study, Santropol Roulant, requires staff to lead workshops, organize events and media inquiries, and coordinate volunteers on top of their typical gardening duties. The commercial case study, Lufa Farms, provides regular tours to school groups and has frequent media inquiries which require staff efforts to organize. Additionally, as a commercial project, Lufa Farms has an online marketplace that requires ongoing resources and maintenance. The Fairmont Hotel, on the other hand, requires less administrative resources as it is a smaller-scale operation and there are

limited people who regularly access the rooftop and minimal marketing. The Hotel website has information about the rooftop, but it does not require regular updating, and there are small rooftop tours provided to guests of the Hotel, which require staff to organize and lead.

A review of policy documents in Montreal indicate that there is very little discussion of policy interventions relating to RA specifically, which may indicate Montreal is still catching up to other winter cities (e.g. Toronto and Vancouver) and how their buildings accommodate green or food productive roofs in better and more complete ways. It appears that the policy improvements seen in recent years are mostly reactive, as Montreal is trying to mitigate the effects of climate change and move toward a more sustainable approach to urban development. The policy improvements are generally more focused on green roofs rather than food productive roofs, but these improvements may nonetheless encourage a more proactive planning approach for RA within the City.

## 7.0 Recommendations

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Among many things, Montreal gets international attention for its densely inhabited downtown core. Having said this, Montreal must work to implement efficient and forward-thinking sustainable development practices, but also educate its citizens, visitors, entrepreneurs and other partners that frequent the City.

This chapter summarizes the previous research and suggests five recommendations for the implementation of RA in the city of Montreal. This section intends to provide insight and possible tools to the City, organizations, businesses, and perhaps homeowners to developing successful RA projects and increasing food security in their city. The recommendations are based on the benefits of RA and overcoming the barriers as discussed throughout this practicum.

### **7.1 Rooftop Agriculture Guidelines**

The development of new RA guidelines could be useful for organizations, businesses, and homeowners considering embarking on a RA project. While there are many resources for RA (for example Mandel, 2013 and Johnson, 2010, to name a few), there are only outdated UA guidelines specific to the city of Montreal. The development of this guide would require resources from the city of Montreal, but it could be an additional tool that has the potential for providing tips on beginning the RA process, including the benefits, local resources, financial incentives available, FAQs, best practices, application processes, construction standards, and planning, zoning, and design information.

### **7.2 Financial Incentives**

The City of Montreal could offer financial incentives to those interested in adopting a rooftop garden. These incentives could encourage more RA throughout the city and could perhaps lead to a more secure local food system and improve sustainability efforts and climate mitigation, which are identified as goals in the City's Master Plan. Currently, there is no financial support that is specific to RA projects in Montreal, so the development of a funding program to support RA and improve local food security may be one way for the City of Montreal to encourage more RA projects within the city limits. As discussed previously, it is unclear whether the commercial case study, Lufa Farms, improves food security in Montreal since it is a for-profit business and their produce is likely unavailable (from a cost perspective) to the majority of Montreal residents who are experiencing food insecurity. Perhaps these financial incentives offered by the City could be developed to benefit organizations similar to Santropol Roulant, which either donate to

Montrealers in need, or sell their produce for a low rate to the general public, as organizations like this have the goal to improve local food security.

### **7.3 Collaboration and Partnerships**

There is the opportunity for businesses, organizations, and homeowners to form collaborative partnerships when it comes to RA projects. These partnerships would very much depend on the scale and context of the RA project. As the maintenance costs of RA are a significant barrier in the development and success of a project, perhaps residents in a multi-family building could form a partnership to share some of the associated costs and maintenance of a rooftop garden. The agreement to have shared and dedicated maintenance individuals or teams would likely ease some of the concerns.

Another potential idea for reducing the workload and incorporating more RA is if organizations or businesses with ideal roofs would rent out their rooftops to groups interested in developing and maintaining RA. This arrangement could be a potential financial incentive for RA developers (they do not need to own the building), and a consistent revenue source for the building owner, for an otherwise unprofitable space.

### **7.4 Agri-tourism**

While Montreal is already an established tourist destination, an increase in RA projects throughout the City could entice tourists. All three case study sites: the Fairmont Queen Elizabeth Hotel, Santropol Roulant, and Lufa Farms all experience a high interest from visitors to see their rooftop gardens. The Fairmont's restaurant promotes that they use the freshest seasonal ingredients from their own rooftop to serve their guests from around the world, Santropol Roulant promotes community development and improved food security, and Lufa Farms invites



visitors in an attempt to educate and reconnect people with where their food comes from. More RA projects could increase agri-tourism in Montreal, therefore potentially strengthening the local economy, providing locals and visitors with an interesting activity, and adding value in educational agri-tourism (the opportunity to see how and where food is grown in the City).

## **7.5 Policies and Planning**

The City currently has a few documents that indirectly relate to RA, such as *Sustainable Montreal 2016-2020*, *Climate Change Action Plan for the Montreal Urban Agglomeration 2015-2020*, the *Montreal Master Plan*, *Système Alimentaire Montréalais (SAM) 2025*, and *Creer un Jardin Communautaire 1996*, a dated guide for developing UA in Montreal.

The City of Montreal has the opportunity to develop new and more comprehensive policies to encourage the production of green roofs and RA. Other cities in North America, such as Toronto and Vancouver, have developed successful green roof and food policies that Montreal could learn from. *Toronto's Green Roof Strategy* and Green Roof Bylaw was established in 2006, and just ten years later, the City was recognized for having the most green roofs in a North American city (City of Toronto, 2009). Toronto has also established the *GrowTO Urban Agriculture Action Plan*, which supports the City's vision for a green and food-secure future (Toronto Food Policy Council, 2012). While some of Montreal's existing policies mention rooftop greening as a goal, the City is still catching up to other Canadian winter cities and has the opportunity to develop a specific green roof policy and action plan that directly encourages RA.

## **7.6 Education**

Lastly, there could be more efforts made by either the City, community organizations, or schools to educate Montreal residents on various aspects of urban and rooftop agriculture, such

as the different methods that are affordable and suitable for small-scale production, how to start a garden, and maintenance and harvesting tips, to name a few. The harvesting tips could be especially important in the context of a winter city. For example, if a resident decides to grow a small container garden and the growing season is only from about June to October, there are 8 months without fresh produce. The educational component could include methods of preserving produce throughout the winter months (e.g. freezing and canning). This could be a cost saving strategy for residents and another step towards improving year-round food security in a winter city.

## 8.0 Conclusions

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With global climate and the increasing cost and environmental implications of transporting food, cities around the world must come up with innovative solutions to securing their food supply.

While it is unclear at this point whether RA can significantly improve local food security, organizations like Santropol Roulant are making improvements and increasing access to healthy food for some Montreal residents experiencing food insecurity. If RA is going to contribute to Montreal's food system, it will require comprehensive RA guidelines, policies, planning, partnerships, and financial incentives.

### 8.1 Implications for the City of Montreal

#### 8.1.1 Structural Changes

To accommodate the structural requirements for developing RA projects on buildings, existing buildings will have to be evaluated by an engineer for their capacity to hold the weight of

agricultural equipment and materials on the roof. Some buildings may already be capable without any major structural changes (in winter cities, many rooftops are developed to support heavy snow loads); however, some may require an overhaul which will likely have significant time and cost implications. As part of a new green roof policy (similar to that of Toronto's discussed previously), Montreal could begin requiring a certain percentage of new buildings' rooftops to be built to support the weight of RA equipment.

### **8.1.2 Green Roof and Local Food Policies**

Montreal could develop a green roof policy that encourages RA. This policy implies that there will have to be structural requirements which would be outlined in a green roof construction guide. This policy development has time and cost implications for the City, as it would take significant resources to establish a new policy. In order to encourage new RA, perhaps it will be a requirement that a certain percentage of new developments in the city must have RA. To encourage more RA, perhaps the city could provide financial incentives for new projects, which would have additional financial implications for the City. The City could also benefit from updating *Creer un Jardin Communautaire 1996*, a dated guide for developing community agriculture in Montreal. This update would require additional resources for the City.

### **8.1.3 Measuring the Success of RA**

If the City of Montreal developed green roof and local food policies that encouraged more RA, there would need to be a monitoring system in place for the City to determine if the increase in RA is making a difference. For example, what impact does RA have on the environment, on local food security, on community development, on social inclusion, on local farmers and grocery

stores, and so on. The development of the monitoring strategy and the monitoring and research itself would require resources from the City.

#### **8.1.4 Implications for Grocery Stores**

It is unclear what impact the development of RA would have on local grocery stores, as many of them currently import a significant amount of their produce for sale. If RA development in Montreal became significant, perhaps grocers would have to conform to the changes and partner with local RA organizations, start selling more local produce, or even start developing their own RA to remain competitive.

#### **8.2 Opportunities for Further Research**

There are various opportunities for additional research relating to RA in Montreal that can be done to complement this practicum. For example, an in-depth analysis of the amount of available rooftop space can be done to better understand the capacity and feasibility of rooftops for food production. A comparative cost analysis of produce sold in grocery stores and produce sold from RA projects, such as Lufa Farms or Santropol Roulant, could be beneficial in assessing whether RA's produce is lower in cost and if it therefore has the ability to improve local food security. A survey could also be useful for better understanding the lifestyle choices of specific Montreal residents, perhaps categorized by borough. This survey would be interesting to understand how lifestyle choices and location affect where Montrealers shop for their groceries, and the types of groceries they most commonly shop for (e.g. types of vegetables). The combination of the spatial analysis, comparative cost analysis, and survey could offer more insight into whether rooftops could satisfy Montreal residents' daily vegetable requirements, lifestyle choices, and budgets.

### 8.3 Closing

The issue of food security is current, and with the global environmental realities of climate change and their impact on food production, there is a clear need for the coordination and development of alternative food sources in Canadian cities. The analysis of this practicum indicates that certain RA projects in Montreal could improve local food security but may be more effective with the thoughtful implementation of both policy and infrastructure interventions. While the conclusions of this research project are specific to RA in the Montreal context, they may be applicable to others looking to become more food secure, resilient, and productive cities.

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## Appendix A: Interview Questions

### Questions for Case Study Participants

1. Can you please describe your professional role at your organization?
2. How many people are involved in the management and maintenance of your rooftop garden?
  - To what extent are they involved (i.e.: are their positions voluntary, paid, etc.)?
3. What is required to maintain your rooftop garden?
  - How many hours per week?
  - What are the costs to the organization?
4. How much food does your organization produce?
  - How is this measured?
  - Who gets it?
5. Your organization's mission is to support and advocate for local food systems.
  - How are you trying to achieve this?
6. a) What do you perceive to be the barriers or constraints related to creating a rooftop agriculture project in Montreal?
  - Potential probes include financial issues, structural factors (converting the roof to support agriculture), technical/horticultural aspects (design, skill, operation aspects), administrative issues (management, maintenance), and/or climate concerns (weather, growing seasons).
6. b) What strategies would you suggest for overcoming these barriers/constraints?
7. What benefits of rooftop agriculture are most important to your organization?
8. What more can be done to support rooftop agriculture projects in Montreal?
  - Potential probes include policy changes, financial assistance (tax incentives, fee rebates, or grants), education, partnership development (non-profit organizations, private companies and government).
9. Is there anything else you would like to speak about?

**Questions for those with Contextual Knowledge (i.e. advocates, academics, planners)**

1. Can you please describe your professional role?
2. How does your work relate to rooftop agriculture?
3. In your opinion, what is the state of rooftop agriculture in Montreal?
4. Can you describe a project that is a good example of rooftop agriculture in Montreal?
  - Why do you think this project is successful?
5. Are there criticisms to growing food on rooftops?
  - If yes, what are they?
6. Do you see rooftop gardens as a viable option for food production in Montreal? Please explain.
7. What do you perceive to be the barriers or constraints related rooftop agriculture in Montreal?
  - Potential probes include:
    - financial
    - structural (i.e. converting the roof to support agriculture)
    - technical/horticultural (i.e. design, skill, operation aspects)
    - administrative (i.e. management, maintenance)
    - climate (i.e. weather, growing seasons)
8. What strategies would you suggest for overcoming these barriers/constraints?
9. What do you perceive to be the benefits of rooftop agriculture in Montreal? Financial (i.e. lower food costs)
  - Potential probes include:
    - environmental (i.e. clean air, less produce travel, animal habitat)
    - community strengthening
    - food production (i.e. less produce travel, locally grown)
10. Can you pass along the Recruitment Letter and Project Summary sheet to anyone who you think may be interested in speaking with me?