Big Shoes to Fill: An Investigation of the Halifax Food Footprint

by

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Submitted in partial fulfilment of the requirements for the degree of Combined Honours Bachelor of Science in Environment, Sustainability and Society & Environmental Science

at

Dalhousie University
Halifax, Nova Scotia
April 2017
Supervised by Dr. Peter Tyedmers
School of Resource and Environmental Studies

DALHOUSIE UNIVERSITY

DATE: April 17th, 2017

AUTHOR: Jordyn Stafford

TITLE: Big Shoes to Fill: An Investigation of the Halifax Food Footprint

DEPARTMENT OR SCHOOL: College of Sustainability

DEGREE: Bachelor of Science Environment, Sustainability and Society and Environmental Science

Convocation: June, 2017

Signature of Author

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Abstract

In response to increasing urbanization and demand for local food, this study aims to contextualize the land area needed to feed urban Halifax, Nova Scotia, through the calculation of a food footprint. Derived from ecological footprinting methodology, this analysis utilizes per capita consumption and Nova Scotia agricultural yields.

The results of the food footprint analysis determine that just over 200,000 hectares of agriculturally productive land are needed to feed the city of Halifax. Currently there are 113,672 hectares being used for commercial agricultural production in Nova Scotia. Therefore, Nova Scotia does not have the capacity to meet the consumption demands of the Halifax population. Due to the restrictive growing conditions of Atlantic Canada's geography and climate, increasing food production capacity is extremely difficult. Thus, further research into, and additional support for, unconventional methods of agricultural production are recommended, as alternative strategies to satisfy the Halifax food footprint.

Acknowledgments

I would like to extend my gratitude to Dr. Peter Tyedmers for his patient guidance and thoughtful insight throughout this thesis writing process. In addition to Dr. Steve Mannell, Professor Andrew Bergel and Dr. Daniela Turk for their encouragement and careful revisions. Dalhousie data librarian Julie Marcoux played an instrumental role in obtaining the optimal data for the footprint calculations.

Chapter 1: Introduction

1.1 Problem

According to the David Suzuki Foundation, a prominent environmental advocacy group, the average meal in Canada currently travels approximately 1,200km from farm to table (2014). Furthermore, a 2005 study concluded that the milk, sugar and strawberries in a single container of yogurt travel on average 3,558 kilometres to the processing plant (DeWeerdt, 2011). These statistics depict a food system that has become: 'centralized, industrialised and complex almost to the point of absurdity' (DeWeerdt, 2011). The vast geographical distance that food travels has contributed to the prevalent disconnect between producer and consumer.

In an attempt to eliminate these fractures in the food system, conscious consumers are choosing to purchase food produced locally. Demand for local food in Nova Scotia is on the rise; from 2004 to 2013 the number of farmers markets in the province increased by 300% (Crawford & Butler, 2013). Thus, Nova Scotia now boasts the highest number of farmers markets per capita in Canada (Crawford & Butler, 2013). A 2013 province-wide survey found that 45% of farmer's market patrons chose to attend in an effort to support the local food movement (Crawford & Butler, 2013). Thus, it is evident that Nova Scotians are becoming increasingly eager to engage in the local food system. However, Nova Scotia is no agricultural mecca. Province-wide, there are just 3,905 commercial farms in operation, contributing only 2.2% to the provincial GDP (Statistics Canada, 2016a; Agriculture and Agri-Food Canada, 2013). Thus, the increasing demand for local food generates queries about whether Nova Scotia agricultural production can support the provincial population.

1.2 Research Purpose and Hypothesis

The purpose of this study is to analyze the impact of urban Halifax's food consumption. Currently the Nova Scotia capital city is home to approximately 403,131 individuals and, as of 2011, there were 113,672 hectares of land being used for agricultural production in the province (Statistics Canada, n.d.b; Grudic & Previl, 2016). To a layperson, this certainly appears to be a large land to population ratio. Thus, one might think that the province, at least on a cursory level, could support the consumption needs of the city. Therefore, this study will test the hypothesis that the urban Halifax population could be sustained on food derived entirely from within the province. The purpose of this test is to gain further insight into the capacity of food production in Atlantic Canada, to better understand the feasibility of local food consumption in Halifax. The results of the study will take the form of a Halifax food footprint; a definitive area of agriculturally productive land required to feed the city.

1.3 Significance of the Study

According to The World Bank in 2015, 82% of the Canadian population lived in an urban setting. Following a wider global trend, this number has been increasing steadily for decades. In this era of rising urbanisation, this study will help contextualize the land required to feed a city (The World Bank, 2015). This context will help inform the discussion surrounding local food and Nova Scotia agricultural capacity, in addition to the Halifax food system as a whole. The discussion may subsequently influence future food and land use policy, as it will further the collective understanding of Halifax's dependency on the surrounding Nova Scotia landscape.

Chapter 2: Literature Review

To calculate a food footprint for the Halifax population, it is critical to first analyze the existing literature regarding the Nova Scotia food system. Identifying the current structure, methodologies, and ideologies associated with food production in the Halifax Regional Municipality (HRM) establishes a framework of understanding upon which further research can be conducted. The following literature analysis will explore current knowledge regarding food consumption and waste patterns, food sourcing, urban agricultural practices and ecological footprinting methodology.

2.1 Food Consumption

Statistics Canada's 2009 *Food Statistics* report continued a two-decade long trend of steadily decreasing levels of beef and pork consumption (Statistics Canada, 2009). This trend reflects the ongoing shift amongst Canadians towards a diet, which includes higher intake levels of fruit, vegetables, cereal products, nuts, and beans (Statistics Canada, 2009). However, in contrast to this evident shift towards a plant-based diet, poultry consumption increased by 3.5 kg a person over the same period (Statistics Canada, 2009). As a result, Canada continues to be among the top consumers of meat in the world, ranking eleventh internationally in total per capita meat consumption in 2016 (OECD, 2016).

Food consumption data does not exist provincially in Nova Scotia. Therefore, it is important to note the potential for deviation within the province from the consumption behaviour reflected in the national consumption data. Food preferences often correlate with age and ethnic background (British Columbia Ministry of Agriculture and Lands, 2006). Thus, due to a pattern of cultural clustering, regional consumption habits likely differ from the national average (British Columbia Ministry of Agriculture and Lands, 2006). According to census data in 2011, 90.2% of the Halifax population reported English only as their mother tongue, in comparison; only 56.9% of Canadians report English only (Statistics Canada, 2012). This stark contrast in languages spoken in Halifax versus national norms, demonstrates that the Halifax ethnic demographic composition likely differs greatly from the federal average. Thus, Halifax consumption patterns and trends may not be accurately reflected in federal consumption data. A study conducted by the *British Columbia Ministry of Agriculture and Lands* saw evidence of regional diet deviation, due, in their context, to the higher Chinese-Canadian population, which consumed larger portions of Chinese cabbage, mushrooms and goat meat (British Columbia Ministry of Agriculture and Lands, 2006).

Unbalanced diets and the overconsumption of food are leading to rising obesity in Atlantic Canada. In 2011, 37.5% of Nova Scotia's population were considered overweight, of which 23.7% were identified as obese (Twells, Gregory, Reddigan, & Midodzi, 2014). Canada has seen a decrease in prevalence of normal weight individuals and a steady increase in all classes of obesity over the past 50 years (Twells, Gregory, Reddigan, & Midodzi, 2014). Projections estimate that by 2019, Nova Scotia will have more overweight than normal weight adults. (Twells, Gregory, Reddigan, & Midodzi, 2014). This could result in a shifting definition of the normal weight classification, as from a statistical perspective the norm would shift upwards with weight gain. Therefore, increasing overconsumption trends will likely impact the Halifax food footprint, causing it to be larger than nutritionally required.

The aforementioned study conducted in 2006 by the British Columbia Ministry of Agriculture and Lands dissected British Columbia's food self-reliance, examining whether British Columbia (B.C.) farmers had the capacity to feed the growing population of the province (British Columbia Ministry of Agriculture and Lands, 2006). The study compared Statistics Canada Consumption data to *The Canadian Food Guide* recommended consumption levels; results of the two differing footprints are depicted below in Figure 1.

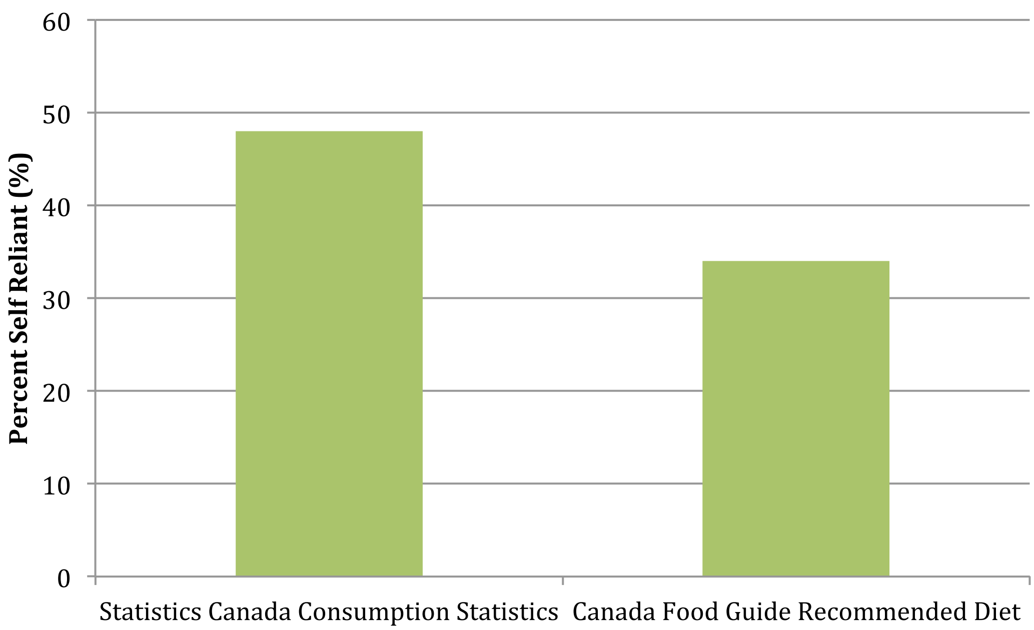
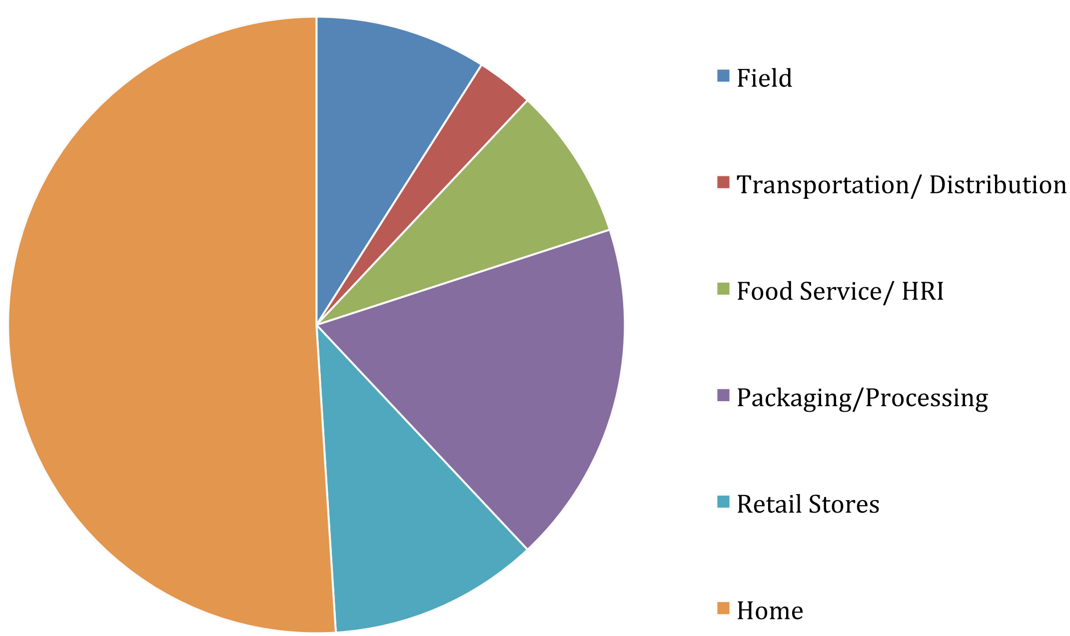


Figure 1. British Columbia Food Self Reliance

The figure demonstrates that the province was 48% self-reliant for all foods consumed based on Statistics Canada consumption data (British Columbia Ministry of Agriculture and Lands, 2006). However, when calculated with the recommended consumption patterns in *The Canadian Food Guide*, British Columbia's self reliance dropped to 34% (British Columbia Ministry of Agriculture and Lands, 2006). This drop was largely due to the fact that a healthy diet recommended by *The Canadian Food Guide* has far higher levels of fruit and vegetable intake than what Canadians typically eat (British Columbia Ministry of Agriculture and Lands, 2006). Therefore, when conducting footprint analyses it is important to note the discrepancies between current consumption behaviour and recommended consumption.

2.2 Food Waste

A substantial proportion of the food produced for human consumption does not contribute to human nutrition (Clark & Francis, 2016). Waste occurs in each phase of the food system; production, processing, transportation, storage and consumption. A comprehensive breakdown of food waste in the system is depicted below in Figure 2.



Note: HRI = Hotel/Restaurant/Institutional food outlets

Figure 2. Percentage of food waste in the Canadian food chain (Gooch, Felfel & Marenick, 2010).

Figure 2 demonstrates that over 50% of food waste in Canada occurs in the home. Food waste is largely determined by how food is valued within a community; in communities of lower disposable income, food holds a higher value and thus is wasted less within the home (Clark & Francis, 2016). As a relatively affluent country, Canadians spend very little of their overall income on food expenditures (Clark & Francis, 2016). In 2014 Canadians spent approximately 10% of their yearly overall expenditures on food. Consequently, this essential commodity is devalued due to its relatively low cost- increasing food waste in the home (Clark & Francis, 2016; Statistics Canada, 2016b).

However, this scale of waste is not the case for all Canadians: in Nova Scotia many individuals struggle with food insecurity (FoodARC, 2016). Food insecurity denotes a state where individuals have inadequate access to sufficient, safe and nutritious food to maintain a healthy and active lifestyle (World Food Programme, 2017). Currently 18.5% of Nova Scotia residents are food insecure (FoodARC, 2016). Among individuals living in food insecurity, food waste in the home becomes far less prevalent: food is increasingly scarce and more effort is made to eke out every ounce of nutrition. It is when food becomes surplus in the home that waste quickly begins to emerge (Clark & Francis, 2016). Understanding the magnitude of food waste in Halifax homes better depicts the gap between food produced for consumption and food which contributes to human nutrition.

As previously depicted in Figure 2, food waste is not entirely due to the actions of consumers; it occurs during each phase of the food chain. A report produced by the *Value Chain Management Centre*, identified 7 factors that created waste, which are listed in Table 1.

Table 1. Identifies the seven factors that contribute to food waste in Canada (Gooch, Felfel & Marenick, 2010).

Factor	**Types of waste that occurs as a result**
Overproduction	Too much production and/or poor flow of products through the chain, often resulting in the need to discount in order to flow products through the system before they spoil.
Defects in products or equipment	Poor quality products, poorly operating equipment, communication errors, shortened shelf life, poor delivery.
Unnecessary inventory	Occurs at any point along the chain, including in households; creates excessive delay, poor customer service, long cycle times, excessive spoilage.
Inappropriate processing	Incorrect procedures or systems, often when simpler approaches would be more Effective.
Excessive transportation	Excessive, often complex and costly movements of products or information
Waiting	Long periods of inactivity result in poor materials or information flow, long lead times, and increased spoilage.
Unnecessary motion	Poor design of any link or workplace along the chain, or the overall chain itself, often leading to lost or damaged items.

Gaining a better understanding of these seven factors allows for adjustments in the food system to reduce overall food waste. Decreasing food waste would significantly benefit the economy and environment in the long term (Gooch, Felfel & Marenick, 2010). A reduction in food waste would additionally lead to a reduced food footprint for the Halifax population, as less land would be required to create the unnecessary food surplus.

2.3 Nova Scotia Agricultural Production

Nova Scotia's natural geography and geology create unsuitable conditions for widespread, bountiful agricultural production. The soil orders present in the province are identified below in Figure 3.

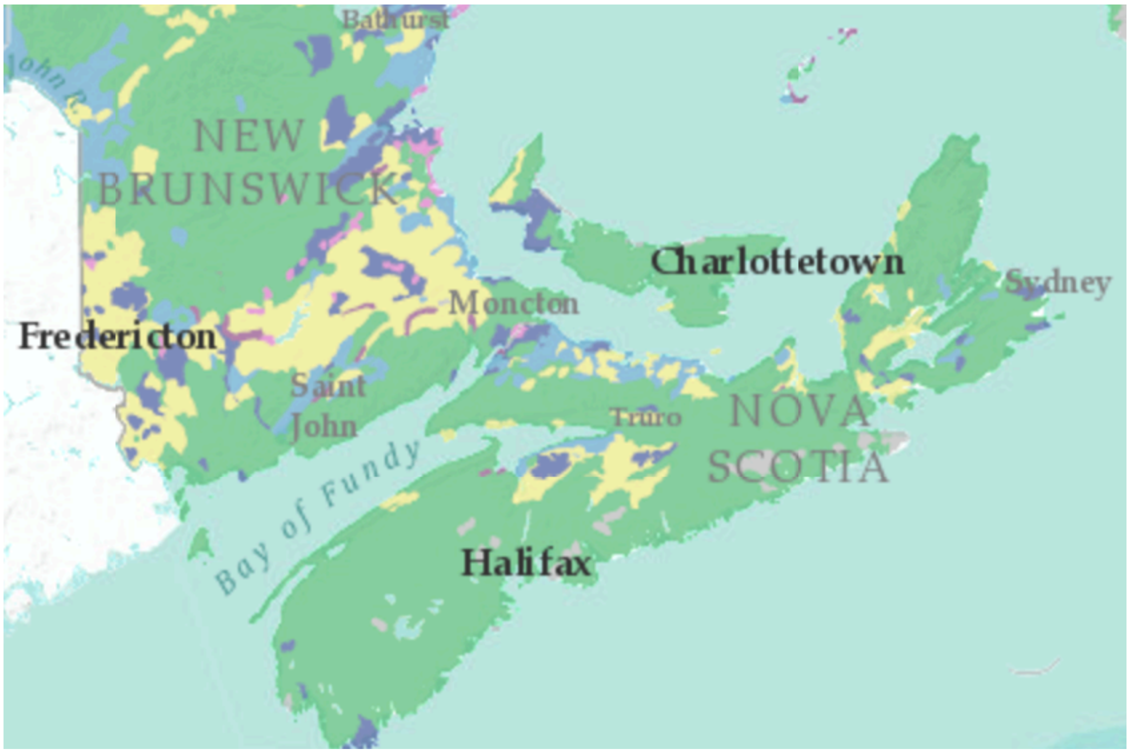
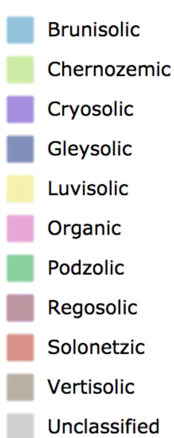


Figure 3. Soil orders found in Atlantic Canada (Agriculture and Agri Food Canada, n.d.).



Podzolic Soil
Forested soils found primarily on sandy parent materials in areas underlain by igneous rocks (University of Saskatchewan, n.d.)

Luvisolic Soil
Forested soil underlain by loamy tills derived from underlying sedimentary rocks (University of Saskatchewan, n.d.)

Gleysolic Soil
Clay-dominated soil textures with very slow rates of water movement through the soil (University of Saskatchewan, n.d.).

The map above demonstrates the widespread presence of podzolic soil in Atlantic Canada. Podzolic soils typically have an acidic pH as a result of the mineralogical composition of the sediments in the region (University of Saskatchewan, n.d.). Due to its high acidity and sandy composition, podzolic soil has a poor agricultural capacity. Thus, Nova Scotia's agricultural potential is limited dramatically by the wide spread distribution of podzolic soil. Nonetheless, some regions such as the Annapolis Valley are home to other soil orders including luvisolic soil . When compared to podzolic, luvisolic soil is more suitable for agricultural production due to its higher moisture availability and organic content (Government of Alberta, 2016). Thus the Annapolis Valley is a region known provincially for its agricultural productivity.

The soil order most suitable for agricultural production is Chernozemic soil, which is present throughout the Canadian prairies (Agriculture and Agri Food Canada, n.d.). The interaction between the roots and mineral material in chernozemic soil results in a granular soil structure, which is highly favourable to air and water movement (University of Saskatchewan, n.d.). This movement evidently benefits plant growth, allowing chernozemic soil to support large-scale agricultural production. However, Figure 3 indicates that this highly capable agricultural soil is not present in Atlantic Canada.

Agriculture and Agri-Food Canada has further developed a land classification scheme to identify and determine soil suitability for agriculture. Table 2 depicts the varying levels of soil available for agricultural production in the Maritimes.

Table 2. Soil Classes Present in the Maritimes (Agriculture and Agri-Food Canada, 2013b; Devanney, 2010).

Soil Class	Class Description	Area in Nova Scotia (hectares)	Area in the Maritimes (hectares)
1	Soils in this class have no significant limitations in use for crops	0	0
2	Soils in this class have moderate limitation that restrict the range of crops or require moderate conservation practices	164,933	647,815
3	Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices	990,062	2,566,838
4	Soils in this class have severe limitations that restrict the range of crops or require special conservation practices.	418,166	2,621,592

In the whole of the Maritimes, there is no class 1 soil present for agricultural production. Thus, more deliberate farming and soil conservation techniques must be used to harvest on local land. Nonetheless, agricultural production continues to contribute to the provincial economy. In 2010 primary agriculture measured in gross domestic product (GDP) contributed approximately $222 million to the Nova Scotia economy (Thibodeau, 2014).

International exports valued at approximately $359 million in 2013 and are considered a major driver of Nova Scotia's agri-food sector (Thibodeau, 2014). In 2013, approximately 61% of Nova Scotia's agriculture and agri-food production was exported (Agriculture and Agri-Food Canada, 2013). The prevalence of Nova Scotian agricultural exports demonstrates an external demand for food produced on Nova Scotia soil.

Dairy, mink and poultry account for the majority of farm cash receipts in Nova Scotia, however other significant contributors include eggs, blueberries, field vegetables, cattle and apples (Thibodeau, 2014). Nova Scotia is home to the second largest blueberry growing area in Canada, with blueberry exports accounting for 63% of the province's agri-food exports to Europe (Statistics Canada, 2016a; Thibodeau, 2014).

2.3 Food Procurement

The Nova Scotia growing season ranges, on average, from 140 to 170 days a year (Agriculture and Agri-Food Canada, 2014). This limited growing season spans less than half a year, thus many foreign food products, which are adapted to grow in warm conditions year round, are incapable of taking root in Nova Scotia. Products such as rice, avocados and mangoes cannot be grown outdoors in the harsh winter conditions and must be imported from more temperate regions of the world. Extensive greenhouse infrastructure and energy would be required to support the growth of these foreign foods locally. The products would come at a high economic and environmental cost and therefore would not be viable for production on a large commercial scale (Liu, 2016).

As of 2009, 32% of all agriculture and food products sold in Nova Scotia were purchased from Nova Scotia producers and processors (Agriculture and Agri-Food Canada, 2013). However, the 2010 Ecology Action Centre (EAC) report *Is Nova Scotia Eating Local?* found that only 13% of the funds spent on food in Nova Scotia went back to Nova Scotia farmers (Scott & MacLeod, 2010). This low percentage demonstrates a huge capacity for growth and transformation in the Nova Scotia food system (Scott & MacLeod, 2010). Currently, Nova Scotia produces nearly twice the amount of fresh and processed apples consumed in the province, while 50% of the apples eaten in the province are imported (Scott & MacLeod, 2010) However, it must be highlighted that not all apple varietals (Fuji apples, for example) are suitable to the Nova Scotia climate (Spurr, 2013). Nonetheless, this evidence highlights an obvious disconnect between production and consumption in Nova Scotia. In addition, regional grocery store data demonstrates that the majority of the food available in the grocery store is from outside Atlantic Canada (Scott & MacLeod, 2010).

The National Nutritious Food Basket (NNFB) is a list of 66 food items that reflect the consumption habits of Canadians while meeting the nutritional standards of the Canadian Food Guide (Scott & MacLeod, 2010). The EAC report determined that the average distance traveled of the entire NNFB to Nova Scotia was 3,976 km (Scott & MacLeod, 2010).

It is evident that a vast majority of the food being eaten in Halifax is grown outside of the province, demonstrating the dramatic theoretical potential for the local food movement. Local food has demonstrated a surplus of advantages including benefits to the local economy, through support for local agricultural producers (Klavinski, 2013). In addition local food is often acknowledged as being of higher quality, containing added flavour and nutrients (Klavinski, 2013).

2.4 Urban Agriculture

Once a food footprint for Halifax is generated, it can be applied to an array of situations to assist in planning, problem solving and general understanding. If more food can be grown within the city boundary, to supplement local consumption, the agricultural footprint outside of HRM can be reduced. A study conducted in Cleveland, Ohio looked at the capacity for conventional agriculture within the city boundaries (Grewal & Grewal, 2012). Due to Cleveland's economic downturn and high rate of foreclosures, there are surpluses of vacant lots throughout the city. These lots have been identified as potential expansion sites for urban agricultural (Grewal & Grewal, 2012). Analysis by Grewal &

Grewal (2012) of brown and green space within the city, concluded that if 62% of every industrial and commercial rooftop, 80% of every vacant lot and 9% of every occupied residential lot were utilised; 46-100% of fresh produce, 94% of poultry and eggs and 100% of honey consumed by Cleveland could be produced within the city limits (Grewal & Grewal, 2012). Their work demonstrated the possibility of repurposing land within a city, and is an example of the way in which Halifax could chose to move forward to diversify food production, and limit the reliance on conventional agricultural land. However, when compared to Cleveland, Halifax has a dramatically smaller area of vacant lots within the city. Since the 1950s Cleveland has experienced loss of population and industry, which resulted in a decrease in demand for land (Dewar, 2009). In contrast, Halifax has seen a rise in value of land over this same period, with rent prices increasing by approximately 75% from 1992 to 2016 (Statistics Canada, n.d.m).

Alternatively, the Bowery Project in Toronto organizes more transient urban agriculture initiatives. Toronto is in a period of dramatic growth and has few long-term vacant lots in the city. However, short-term vacancies are prevalent during early stages of planning and development. The Bowery Project uses milk crate garden beds to grow on short-term vacant land, which allow gardens to be quickly decommissioned and relocated when the lot is once again in demand (The Bowery Project, n.d.). For Halifax, a city with minimal vacant land, a project like this may be more suitable to diversifying urban agriculture initiatives.

Small-scale urban agriculture practices, such as community gardens, are also on the rise in Halifax. Currently there are 11 community gardens in operation on public land in the urban area of the HRM (Halifax Regional Municipality, 2017). The municipality is encouraging an increase of gardening initiatives and has made efforts to make the garden development process transparent and approachable.

2.5 Ecological Footprinting

Ecological footprinting is a tool used to contextualize environmental impact, by displaying the biologically productive land required to support a population or activity (Global Footprint Network, 2017). Global hectares (gha) are the unit of measurement used in ecological footprint analysis; they address the fact that different land types have different productivities by utilizing the world average biological productivity for a given year (Global Footprint Network, 2017). Ecological footprints have become a popular tool for visualizing consumption and facilitating behaviour change. However, there are a number of strengths and weaknesses involved in their use identified below in Table 3.

Table 3. Advantages and Limitations of the Ecological Footprint (Moffatt, 2000).

Advantages	**Limitations**
Unambiguous message	Is an area unit a suitable measure?
Simple to calculate	Ignores technological change
Includes trade	Ignores underground resources
It is simply stated with a stock answer	Ignores flow
	Lacks measures of equity
	No policy prescriptions

A study conducted by the Federation of Canadian Municipalities in 2005 found that the ecological footprint of HRM was 7.83 global hectares per capita (Wilson & Anielski, 2005). That is an approximation of the land required to produce all of the biogenic products and resources consumed by the HRM population and assimilate most wastes generated. The HRM footprint ranked slightly above the national average of 7.25 global hectares per capita, due to above average consumption and expenditure patterns in the municipality (Wilson & Anielski, 2005).

Cropland, a component of the ecological footprint, indicates the area of agricultural land required to produce the crops that an individual consumes. According to the report by Wilson & Anielski (2005) the HRM cropland footprint was 1.35 gha per capita. The cropland footprint was calculated using publically available municipal food expenditure and consumption data (Wilson & Anielski, 2005). Additional components listed in an ecological footprint related to food consumption are pastureland and sea space. Collectively the cropland, pastureland and sea space footprint totalled 1.69 gha per capita, approximately 25% of the total ecological footprint (Wilson & Anielski, 2005). The other 75% of the footprint was contributed to forestland, built area, hydro reservoir, and energy land.

An ecological footprint is a moderately comprehensive analysis that examines the impact of all inputs and outputs of human consumption and waste production; in contrast a food footprint has a far narrower scope. It will hone in on the food input aspect of the analysis and generate an understanding of the biologically productive land required to meet the dietary consumption behaviour of humans. Understanding the methodology used in calculating ecological footprints will assist in the process of determining the best practice for computing a food footprint for the Halifax population.

General assumptions can be made regarding the Halifax food footprint based on previous studies of the HRM ecological footprint. However, there remains a gap in the literature regarding a current and specific understanding of the relationship between local agricultural production and consumption. Key issues influencing regional agricultural production include soil quality and climate. Meanwhile local consumption levels are influenced by over consumptive behaviour, and food waste. By constructing a Halifax food footprint this study aims to address this gap using current consumption patterns, and local production capacity.

Chapter 3: Methods

3.1 Research Design

This study sets out to quantify the total area of regional agricultural land that would be required to generate the food consumed by the residents of urban Halifax. This analysis utilizes publically available data, to ensure its completion within academic time constraints. The analysis is conducted on a per capita basis, and then scaled using population as a multiplying factor. Because of this design, the results can be further manipulated to represent the needs of different population sizes throughout Nova Scotia.

3.2 Materials

To calculate the Halifax food footprint, two main data sets are utilized: per capita food consumption and Nova Scotia agricultural yields. To obtain the data preliminary web research on Google, Statistics Canada, and Web of Science were conducted using the key search terms: consumption, agricultur* yield, agricultur* production, Halifax, Nova Scotia and Canada. This provided a general understanding of relevant data, where upon further discussion with specialized data, biology, and agriculture librarians at Dalhousie provided additional resources and insight. The final datasets used are from the *Canadian Socio-economic Information Management System* (CANSIM) tables, obtained through the Dalhousie libraries database using the *Computing in the Humanities and Social Science* (CHASS) distributor. To obtain the relevant tables three key search terms are used: yield, consumption and production.

3.2.1 Food Consumption Data

Halifax food consumption is characterized using the Statistics Canada 2015 *Food Available in Canada* data set, identified as CANSIM table 002-0011 (Statistics Canada, n.d.a). The data from this CANSIM table that is used in this analysis appears in Appendix 1. The data demonstrates the food available for consumption in Canada on a per capita basis, broken down by kilograms available of each distinct commodity.

Fruits and Vegetables

Individual fruit and vegetable commodities are further divided into subsections, wherein the different forms the food takes are expressed. For example, apples are composed of seven sub-forms: fresh, canned, dried, frozen, juice, pie filling, and sauce. Conveniently, for each subsection that undergoes processing or refinement prior to consumption, the fresh equivalent weight is provided in the CANSIM data. Therefore, the fresh equivalent weights of each commodity subsection can be amalgamated into a single value. This value depicts the total mass of the fruit or vegetable commodity needed in its original harvested form.

Meat

In the CANSIM data, fowl meats are expressed as boneless weight and eviscerated weight equivalents, whereas livestock meat types are expressed in three forms: plain weight, carcass weight and boneless weight. For meats that come from the same animal such as beef and veal, they are communicated both individually and collectively in the three weight categories.

Dairy

All dairy products are expressed in two weights, the products in the form they were consumed, and in their milk solid equivalent. For the purposes of this research they are compounded in the calculations into a single milk solid value.

Sugar

All sugar products are portrayed in their consumed form, in addition to the sugar content weight. Thus similar to dairy products, they are compounded in the calculations into one sugar content weight, which was assumed to be maple sugar produced from Nova Scotia maple trees.

3.2.2 Yield Data

Growing conditions vary dramatically by region due to differences in precipitation, temperature, nutrient availability and sunlight. Agricultural yield is a direct representation of the impact of growing conditions. Thus, locally specific yield data is used to ensure the footprint reflects the agricultural production rates of Nova Scotia land. The most recent yield data is obtained from Statistics Canada's CANSIM tables 001-0010, 001-0013, and 001-0014, the data used from these tables has been combined and attached in Appendix 2. Yields are represented in the form of kilograms produced per hectare per year (Statistics Canada, n.d.h; Statistics Canada, n.d.j; Statistics Canada, n.d.k).

In the cases that yield data is unavailable in this form due to inconsistencies in Statistics Canada's reporting method, yields are derived from production and agricultural area data. Production data is obtained from CANSIM tables 10-009 and 10-012, and depicted in the form of total kilograms produced annually per given commodity (Statistics Canada, n.d.g; Statistics Canada, n.d.i). Agricultural land area data is presented in the form of total hectares of land used in Nova Scotia to harvest a given commodity, and is found in CANSIM tables 10-009 and 10-012 (Statistics Canada, n.d.g; Statistics Canada, n.d.i).

For maple sugar, further information from the University of Vermont's Proctor Maple Research Center was used to contextualize how much sap would be required to produce the maple sugar content needed, and the average sap yield per hectare. (The University of Vermont, 2017).

3.3 Conversion to Local Food Equivalents

Due to the short growing season and harsh climate of Nova Scotia, many of the foods consumed cannot be produced regionally. Thus calorie equivalencies are used to convert foreign foods into quantities of comparable local food. The United States Department of Agriculture (USDA) food composition database is used to identify calories found within a kg of a particular foreign commodity. In this study, a local equivalent is chosen that reflects key attributes of the foreign food. A calorie comparison is then conducted between the two foods to determine how much of the local food must be consumed to obtain equivalent caloric intake. For example, pineapples cannot grow in Nova Scotia and are therefore represented as apples for the purposes of this calculation. A commodity specific summary of the calorie conversions is available in Appendix 3.

3.4 Sub calculations for animal products and by-products

The footprint calculations for animal products and by-products require a multi-step process. For each commodity this process varies based on the best-suited data available, and is further discussed in the sub-sections below.

Beef

To identify the live weight equivalent of beef per capita consumed, a carcass to live weight conversion is made using data from Wood & Beranek (2014). It is then necessary to quantify the mass of feed inputs required to grow the live weight mass of beef consumed. This is done using feed conversion ratio information retrieved from the Canadian Beef Cattle Research Council (BCRC, 2017). Using the yield data described in section 3.3.2 the land area required to generate beef feed can be derived, producing a footprint for per capita beef consumption.

Chicken

Similarly, a boneless weight to live chicken weight conversion is conducted to generate an estimate of the mass of live chicken that is required per capita. A feed conversion ratio obtained from a 2008 study conducted by Nathan Pelletier on the US broiler industry, is used to quantify the amount and type of feed inputs required to produce the necessary chicken mass (Pelletier, 2008). Using yield data described in section 3.3.2 the land required to generate this feed can be calculated and a footprint obtained.

Pork

Due to inconsistencies in the available data, the pork footprint is conducted using an alternative procedure to that of chicken and beef. The best available data for pork feed represented the kilograms of feed required per day to sustain a pig, which varied based on which stage of life the pig was in (Pelletier, Lammers, Stender, & Pirog, 2010). Thus pig development phases are then examined to determine how many days a commercially produced pig spends on average in each stage of its life (National Swine Registry, n.d.). Once these days are identified the total feed required to sustain a pig throughout its full lifespan can be determined. Using yield data described in section 3.3.2 the land required to generate said feed is calculated, and the total land required to support a single pig is determined. However to maintain consistent units in the footprint calculations the average slaughter weight of a pig is used to determine the land needed per kilogram of pork (Pelletier et. al, 2010).

Eggs

Information obtained from Pelletier, Ibarburr, & Xin's 2014 study of the lifecycle environmental impact of the American egg industry, provided data for the amount of feed required per kilogram of eggs produced. This was used to determine what mass of feed is required to generate the eggs consumed per capita. This feed mass is then deconstructed to reflect the diet of layer hens. Yield data described in section 3.3.2 is used to determine how much land would be required to generate the feed needed to support the laying hens in their egg production.

Dairy

A milk solid to liquid milk conversion is made to determine how much liquid milk must be produced to obtain the necessary milk solid mass consumed annually per capita from CANSIM data (Newman, 2015). Additional information obtained from Newman's 2015 dairy statistics report is then used to determine the average daily milk output of dairy cows. This information is used to determine how many days of milk production must occur to meet the per capita consumption needs. Daily feed requirements for cows in each phase of the dairy system are obtained from Arsenault, Tyedmers, & Fredeen's 2009 paper on the life cycle impacts of dairy systems in Nova Scotia. These daily feed requirements are then multiplied by the days needed for the system to operate to meet per capita demand. The resulting diet is then examined using yield data described in section 3.3.2 to determine how much land would be needed to generate the feed to support the entire dairy production system for the determined period of days.

3.5 Assumptions

A number of assumptions must be made during the calculation of the food footprint. Table 4 summarizes all major assumptions and their consequent limitations. Further commodity specific assumptions are available in Appendix 4.

Table 4. Depicts all major assumptions and related limitations in the calculation process.

Major Assumption	Consequent Limitation
Halifax per capita food consumption patterns reflect Canadian average data used	Any local variations in consumption habits from the national average will not be accounted for
CANSIM consumption data represents purchased food, therefore any food purchased and then left to waste (not consumed) will still be considered consumed for the purposes of this calculation	The footprint will not be derived from true human consumption
Conventional agricultural practices used for production	Any alternative food production techniques (ex. organic) which may produce different yields will not be considered in the calculations
Consumption patterns would remain steady when using local food equivalents	If food consumption patterns differ when limited to eating local food, it will not be accounted for in the calculations

3.6 Data Analysis

To calculate the area required to support the consumption of the urban Halifax population the aforementioned data sets are compiled into an Excel workbook. Calculations are then conducted in a single master calculation spreadsheet. All minor calculations required to format the data to fit the equations (ex. Calorie conversions) are conducted in separate sheets and the results transferred to the master calculation spreadsheet. Using Excel functions, the three equations identified below are applied to the data to derive a final footprint result. Due to the nature of the consumption data conversion factor methods were not required in the equations for the raw equivalents were provided.

Equation 1: $L_i = N_i/Y_i$

Where
$_i$ = individual (per capita)
L_i = land area required to grow singular commodity to sustain yearly per capita consumption (hectares)
N_i= the amount of a singular food commodity consumed per capita a year (kilograms)
Y_i= Annual yield of singular commodity under average Nova Scotia growing conditions (kilograms/hectare)

Equation one uses raw consumption and yield data to identify the land area needed for an individual commodity on a per person basis.

Equation 2: $L_p = \sum_{n=1}^{N} L_{in}$

Where
L_p = land needed per person (hectares)
L_i = land area required to grow individual commodity to sustain yearly per capita consumption (hectares)

Equation 2 builds off of the results obtained with equation 1; it sums all the land needed per commodity and presents the total land need per person.

Equation 3: $L_t = L_p \times P$

Where
L_t= Total land required to feed urban Halifax (hectares)
L_p = land needed per person (hectares)
P = Population of urban Halifax

Equation 3 is the final equation used in the footprint calculation process. It takes the total land area needed to feed an individual in Nova Scotia and multiplies it by the urban Halifax population to determine the Halifax food footprint.

3.7 Guidelines for Interpretation of Results

Applying equations 1, 2 and 3 provides the calculated land footprint to sustain production of all food required to support the urban population of Halifax. To contextualize the result it can be further compared to the agricultural land available in Nova Scotia and the Maritimes discussed in section 2.3 and further examined in Table 2. This will shed light on the capacity of the local and regional food production capacity to feed the local population. In addition the per capita result can be scaled for different regions to gain an understanding of if the system could support local food consumption of different Nova Scotia populations.

Further interpretation should be done on the composition of the food footprint to generate an understanding of the extent each commodity contributes to the total footprint.

Chapter 4: Results

4.1 Key Findings

The data analysis process described in section 3.7 yielded the results depicted in Table 5. The table indicates that, based on conventional agricultural techniques and Nova Scotia agricultural yields, it would require 0.5 hectares of agriculturally productive land to feed an individual in Nova Scotia for a year. Therefore, to feed the urban population of Halifax it would require approximately 201,000 hectares of land. Given that Nova Scotia currently has 113,672 hectares of land in agricultural production, to feed urban Halifax, agricultural land in Nova Scotia would have to increase by an additional 77% based on current farming practices. Alternatively, it would require 72% of all the agricultural land in Nova Scotia, Prince Edward Island and New Brunswick to feed the population of urban Halifax.

Furthermore, Table 5 demonstrates that to feed the entire population of Nova Scotia it would require 473,000 hectares of local agricultural land. This indicates that agricultural land within the province would need to grow to over 4 times its current size to support the provincial population. Alternatively, if all the agricultural land in the Maritimes was considered, total productive land would still need to increase by 69% to solely feed the population of Nova Scotia.

Table 5. Depicts the final footprint calculations presented as per capita, Halifax and Nova Scotia populations. The populations in the table are obtained from statistics Canada (Grudic & Previl, 2016; Statistics Canada, n.d.l).

Region	**Population**	**Total Land Needed (hectares)**	**Percentage of Nova Scotia Agricultural Land (%)**	**Percentage of Maritime Agricultural Land (%)**
Per Capita	-	0.5	0.00044	0.00018
Halifax Urban	403,131	200,000	177	72
Nova Scotia	949,500	473,000	416	169

4.2 Footprint Composition

The food footprint is composed of three major sub components: plant products, meat products and animal by-products. Further analysis of the urban Halifax footprint demonstrates that meat products demand 45,600 hectares of agriculturally productive land, constituting 23% of the total food footprint. Animal by-products require 59,300 hectares for the Halifax urban population, constituting 30% of the footprint. The final 96,000 hectares or 48% of the food footprint is required to generate the direct plant-based components of the diet for the Halifax urban population.

This indicates that the food footprint is composed of roughly half direct plant-based consumption and half animal or animal related consumption. However, analysis of the diet by mass demonstrates that direct plant-based consumption constitutes 88% of an individual's diet, where meat consumption is 8%, and animal by-products 4% of the total diet mass. This displays a significant contrast between contribution to diet and contribution to food footprint, which is further depicted below in Figure 4.

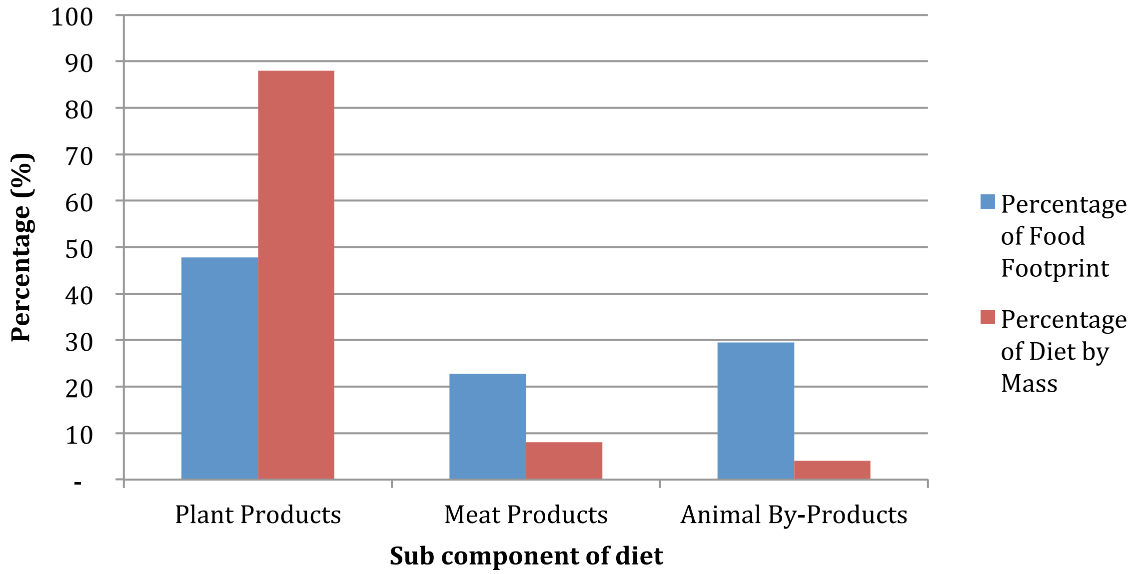


Figure 4. Compares the subcomponents of the diet on their contribution to the total diet mass versus their contribution to the total footprint.

4.3 Plant-based Consumption

44 locally produced individual commodities were identified from the 131 plant-based consumption data values obtained from CANSIM table 002-0011 (Statistics Canada, n.d.a). Of these 44 commodities the ten largest contributors to the plant-based footprint are listed below in Table 6.

Table 6. 10 Largest Plant-based contributors to the food footprint broken-down by mass consumed and land required

Commodity	Mass Consumed Per Capita (kilograms)	Land Needed Per Capita (hectares)
1. Soybeans	334	0.12
2. Honey	1	0.06
3. Wheat	63	0.013
4. Potatoes	155	0.011
5. Apples	107	0.006
6. Blueberries	9	0.005
7. Watermelons	11	0.0025
8. Lettuce	10	0.0025
9. Celery	3	0.0024
10. Beans	6	0.002

In this study, all oils consumed by the population were derived from soybeans. Due to soybeans relatively low capacity to produce oils and fat an extremely high quantity of soybeans was required per capita. Therefore, a large area of land was required to meet the soybean demand driving up the total soybean footprint and ranking it in first place for plant-based food footprint.

In contrast, total honey consumed per capita was very low; however, honey production required a large area of land. According to the Canadian Honey Council to produce a kilogram of honey over 5.6 million flowers must be visited, thus conventional wisdom suggests that an acre of land is needed to support a single colony of bees (Canadian Honey Council, 2017). Therefore, to support the colonies producing the honey, a large land area was needed, ranking the honey land area second amongst plant-based food footprints. On the other hand, it must be noted, that honeybees can collect their nectar from blossoming flowers of other agricultural crops, thus, there is a potential for over estimating the land needed to sustain honey consumption patterns.

4.4 Meat Consumption

When comparing the footprints of each livestock commodity little correlation can be found between mass of meat consumed and land needed to support the commodity. Evidence of this is seen in that chicken represented the largest meat mass consumed, however, required the smallest land area. While pork constituted the smallest meat portion in the diet, however, required the largest land area. The footprints of each meat commodity are depicted below in Table 7.

Table 7. Meat footprint breakdown by mass consumed and land required

Commodity	Mass Consumed Per Capita (kilograms)	Land Needed Per Capita (hectares)
1. Pork	23	0.06
2. Beef	26	0.03
3. Chicken	32	0.02

4.5 Animal By-Product Consumption

The large animal by-product footprint can be attributed to the consumption of milk solids. Milk solids became the baseline milk product required for all dairy products consumed by the population including ice cream, cheese and butter. To produce the necessary milk products an elaborate dairy system must be supported beyond just lactating cows, including heifers of all ages, and dry cows. Producing the feed necessary to support the development of all of these cows drives up the land needed to produce milk solids to be the single largest contributor to the food footprint.

Table 8. Animal by-product footprint breakdown by mass consumed and land required

Commodity	Mass Consumed Per Capita (kilograms)	Land Needed Per Capita (hectares)
1. Milk Solids	23	0.14
2. Eggs	14	0.004

Chapter 5: Discussion

5.1 Results in Connection to Existing Literature

This study found the Halifax food footprint to be 0.5 hectares per capita, an area strikingly small when compared to 1.35 gha of cropland area determined as part of the *Federation of Canadian Municipalities* 2005 HRM ecological footprint study (Wilson & Anielski, 2005). Comparing these two footprints proves a challenge however, for the footprints themselves examine different scopes of crop production. This research focuses solely on the land area needed to produce crops for food. Whereas a cropland ecological footprint additionally considers the land area needed to produce oil crops, fibre crops, cotton, jute, rubber and tobacco (Wilson & Anielski, 2005).

Nonetheless this significant difference in results could be a result of a number of additional factors including variation in land productive capacity. The 2005 study used average global productivity yields expressed in gha. In contrast, the calculations in this study were highly localized and based strictly on the biological productivity of Nova Scotia. The report did not provide the global biological productive capacity values used. However, if the Nova Scotia values prove higher than the global average, less land would be required to yield an equal volume, reducing overall footprint size.

Additional causes of variance could be a result of the use of local equivalencies. Foreign foods may require alternative land areas to generate the equivalent calories of their selected local counterpart; this could therefore result in fluctuation of the footprint.

Finally, in the time since the 2005 study agricultural production techniques have evolved, allowing for increased yields on less fertile soil. This can be seen in analysis of Nova Scotia wheat yields, which from 2005 to 2016, demonstrated a 26% increase in kilograms produced per hectare (Statistics Canada, n.d.h). A comparison of 2005 and 2016 potato crop yields saw an 11% rise, while beet yields have increased by over 600% (Statistics Canada, n.d.k; Statistics Canada, n.d.j) While an increase in yields over the past decade is the case for many commodities in Nova Scotia, some have experienced a decline; Nova Scotia sweet corn yields in 2016 decreased by 20% compared with 2005 rates of production (Statistics Canada, n.d.j).

A 1996 study found the Nova Scotia food footprint to be 3.66 hectares per capita, a value also significantly higher than the 0.5 hectares per capita footprint calculated in this study (Wilson, Colman & Monette, 2001). Reasons for the large variance between these two footprints could be a result of the seafood footprint. Due to the limited scope of this study, all seafood consumed was assumed to be chicken. In the 1996 study the seafood footprint was reported at 1.13 hectares per capita, or 31% of the total food footprint (Wilson, Colman & Monette, 2001). The seafood footprint in combination with the meat footprint represented 86% of the total food footprint (Wilson, Colman & Monette, 2001). In comparison, this study found total animal based consumption to constitute 23% of the total food footprint. Thus, seafood alone had a higher food footprint than all animal based consumption in this study. The large variation between the 1996 footprint and the footprint produced in this study can likely be partially attributed to the conversion of seafood to chicken, as it neglected to consider the differences between land and water production systems. Additional variations between the two footprints could be a result of the aforementioned factors including shifting agricultural yields over time, and the use of local food equivalencies.

When compared to British Columbia's food self-reliance study previously discussed in chapter 2.1, Nova Scotia proved much less self-sufficient. Results from the B.C. self-reliance study indicated that the province currently produces 56% of the total food consumed by the provincial population (British Columbia Ministry of Agriculture and Lands, 2006). In contrast, Nova Scotia has the current agricultural capacity to produce 24% of the food consumed by the provincial population (as depicted in Table 5). British Columbia's temperate weather allows for longer growing seasons, which can produce larger and more numerous yields. In all of Atlantic Canada, 42% of land has a growing season that spans longer than 100 days; while in British Colombia 66% of land has a growing season greater than 100 days (Agriculture and Agri-Food Canada, 2014a; Agriculture and Agri-Food Canada, 2014b). Meanwhile, as of 2011 British Columbia had 81% more agricultural land than Nova Scotia (Statistics Canada, n.d.b). Therefore, although the British Columbia population sits at approximately 4,751,612 people, almost 5 times larger than the population of Nova Scotia, British Columbia has the capacity to be more self-sufficient (Government of British Columbia, n.d.).

5.2 Limitations

The scope of this study was largely limited by time constraints, which were a result of the rigid academic calendar, in addition to outside demands on the researcher during the period this analysis was conducted. As a result, this study neglected to consider the beverage consumption of alcohol, coffee, tea and soda. Canadians consume 318 litres per capita of these beverages a year, the land needed to produce the primary products for this large volume of beverages is not considered in the footprint (Statistics Canada, n.d.a).

Therefore the exclusion of beverages likely has a notable impact on the overall food footprint.

Obtaining regionally specific food consumption data proved to be a large limitation in calculating accurate results that reflected the local area. Lastly, the harsh growing conditions of the Nova Scotia climate limit a strictly local diet, requiring that calorie equivalent assumptions be made as described in section 3.3. Nearly 14% of the total mass consumed annually per person was converted to alternative local commodities for the purpose of this study. Thus, these assumptions limit the overall accuracy of the results obtained.

5.3 External Reliability of Results

Due to the fact that the calculations were generated using Nova Scotia agricultural yields the footprint could not be applied to populations outside of the province of Nova Scotia. To adapt to this limitation yield data for other regions in Canada can be substituted into the model.

5.4 Implications of Study

Food System Resilience

The magnitude of the gap between the Halifax food footprint and the local land available to produce food, demonstrates the substantial dependence the city has on external food inputs. This dependency creates vulnerability within the food system. A study of the resilience of long and short food chains in Queensland, Australia, found that localized food supply chains, which rely on growers in peri-urban areas, and community-based food initiatives are more resilient when compared to their longer counterpart (Smith, Lawrence, MacMahon, Muller & Brady, 2016). In the event of severe weather conditions, food supply chains that rely more heavily on external food sources experience significant difficulty (Smith *et al*., 2016). With this in mind, Halifax's dependency on external food sources creates significant vulnerability for the urban population in the case of severe weather events. Currently, Highway 104 is the sole major road into the province; therefore, in the event the highway closed due to severe weather, Nova Scotia would be cut off from external food inputs via land (Google Maps, 2017). Continued support for alternative and localized agricultural production is a recommended solution to building a more resilient and multi faceted food system capable of managing severe weather events.

Local agricultural production is taking root in urban Halifax, as discussed in Chapter 2, the Municipality of Halifax is making efforts to increase community gardens in the city. Darren Hirtle the community garden coordinator for Dartmouth emphasized in an interview that the application process for gardening on municipal land is indeed straightforward, and both he and the city aim to help and encourage garden start-ups, not act as a barrier to them (D. Hirtle, personal communication, February 17, 2017). Furthermore, HRM District 6 Councillor Tony Mancini discussed in interview, the city's general interest and support for the expansion of community gardens on both publically and privately owned land in urban Halifax (T. Mancini, personal communication, February 7, 2017). It is evident that the Halifax Municipality has recognized the benefits of urban agriculture initiatives and thus there is a growing support for their increased development.

Agricultural Land-Use Planning

Additional discourse regarding agricultural land-use planning is essential. Currently 55% of urban land in Nova Scotia is classified as class two, three or four soil, and therefore is considered agriculturally viable (Devanney, 2010). Specifically, 25% of urban development within the Halifax Regional Municipality has occurred on agriculturally viable soil (Devanney, 2010). From 1998 to 2010 approximately 3,500 hectares of agricultural land was lost to urban development in Nova Scotia (Devanney, 2010). A 300-foot setback is used to mitigate development conflict between farmers and urban residents, however this buffer zone further limits the land that can be used for agricultural production. As of 2010 roughly 30% of farmland in Nova Scotia is within 300 feet of the boundary of properties that are small enough to either currently be developed, or to be relatively easily developed (Devanney, 2010). Therefore, it is evident that a significant portion of agricultural land in Nova Scotia faces issues associated with urban encroachment on farmland. Currently Nova Scotia does not have enough agricultural land to support provincial consumption. Threats to Nova Scotia farms from encroaching development must be mitigated to protect the province's limited agricultural land and prevent a greater exacerbating of the productivity gap.

Consumption Habits

Analysis of the urban Halifax food footprint composition depicted in Figure 4 demonstrates that over half of the footprint land area was a result of animal and animal by-product consumption, however these commodities composed only 12% of the total diet mass. Therefore, it is clear that animal and animal by-products have a disproportionate contribution to the food footprint when compared to plant-based consumption. Thus, decreasing animal related consumption is a suggested method of reducing the overall land area of the urban Halifax food footprint. This recommendation was also made in a study that examined potential mitigation of the environmental impacts of food systems through urban and peri-urban agriculture (Benis & Ferrao, 2017). The study found that animal-based products were associated with the highest environmental impacts, and therefore, impact mitigation increases as the intake of those products decreases (Benis & Ferrao, 2017). Furthermore, the study concluded that the highest potential for environmental impact mitigation is through dietary changes (Benis & Ferrao, 2017).

Additional consumption habit alterations including reducing over consumption and mitigating food waste would work to reduce the urban Halifax footprint. A report conducted by the *Food and Agriculture Organization of the United Nations* (FAO) examined the carbon footprint of wastage by commodity (FAO, 2013). The study found meat waste to be the primary contributor to the North American food wastage carbon footprint (FAO, 2013). Observation of Figure 2 demonstrates that over 50% of food waste occurs in the home, therefore, altering consumption habits to reduce waste in the home would result in a reduced carbon footprint. Furthermore, given that the Halifax urban food footprint is disproportionately attributed to meat production, a reduction in meat waste would result in a decrease in the overall food footprint.

Chapter 6: Conclusion

Nova Scotia's current agricultural production cannot support the food consumption of the Halifax population. Accommodating the growing demand for local food would require a dramatic increase in regional agricultural production. However, due to the restrictive growing conditions of Atlantic Canada's geography and climate, increasing food production is extremely difficult. The need to strengthen Halifax's self sufficiency is critical to building a resilient food system. Thus, further research into, and additional support for, unconventional methods of agricultural production are recommended as alternative strategies to satisfy the urban Halifax food footprint. Simultaneously lessening animal-related consumption, overconsumption and food waste are recommended to reducing the urban Halifax food footprint and creating a more transparent, localized food system.

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Appendices

Appendix 1. 2015 Canadian Consumption Data

Commodity	Food available (kg per person)
Wheat flour	58.11
Breakfast food	5.05
Rye flour	0.22
Oatmeal and rolled oats	0.74
Pot and pearl barley	0.26
Sugar refined, sugar content	29.24
Maple sugar, sugar content	0.27
Honey	1.14
Baked and canned beans	1.06
Peanuts	3.07
Tree Nuts	1.29
Cheddar cheese, milk solids	2.01
Processed cheese, milk solids	0.96
Variety cheese, milk solids	3.56
Cottage cheese, milk solids	0.13
Powder skim milk, milk solids	0.63
Powder buttermilk, milk solids	0.28
Powder whey, milk solids	0.43
Other whole milk products, milk solids	0.34
Concentrated whole milk, milk solids	0.15
Concentrated skim milk, milk solids	0.15
Sweetened concentrated skim milk, milk solids	0.01
Milkshake, milk solids	0.02
Ice cream, milk solids	0.54
Ice milk, milk solids	0.26
Standard milk 3.25%, milk solids	1.25
Buttermilk, milk solids	0.03
Partly skimmed milk 2%, milk solids	3.83
Partly skimmed milk 1%, milk solids	1.56
Skim milk, milk solids	0.54
Chocolate drink, milk solids	0.68
Cereal cream 10%, milk solids	0.63
Table cream 18%, milk solids	1.04
Whipping cream 32% or 35%, milk solids	0.5
Sour cream, milk solids	0.24

Yogurt, milk solids	1.27
Butter, milk solids	2.19
Chicken and stewing hen total, boneless weight	21.06
Fresh and frozen sea fish, edible weight 11	2.84
Processed sea fish, edible weight 11	2.6
Total shellfish, edible weight 11	1.23
Freshwater fish, edible weight 11	0.89
Turkey, boneless weight	3.29
Eggs 15	13.81
Pork, carcass weight	22.63
Beef and veal total, carcass weight	25.27
Mutton and lamb, carcass weight	1.04
Margarine, fat content	2.41
Salad oils, fat content	14.16
Shortening and shortening oils, fat content	6.11
Apples fresh, fresh equivalent	10.94
Apples canned, fresh equivalent	0.1
Apples dried, fresh equivalent	0.32
Apples frozen, fresh equivalent	0.07
Apple juice, fresh equivalent	6.58
Apple pie filling, fresh equivalent	0.11
Apple sauce, fresh equivalent	0.54
Bananas fresh, fresh equivalent	15.67
Dates fresh, fresh equivalent	1.5
Guavas and mangoes fresh, fresh equivalent	1.47
Kiwis fresh, fresh equivalent	0.55
Papayas fresh, fresh equivalent	0.41
Pineapples fresh, fresh equivalent	2.89
Pineapples canned, fresh equivalent	1.12
Pineapple juice, fresh equivalent	1.24
Fruits not specified fresh, fresh equivalent	0.54
Fruits not specified canned, fresh equivalent	2.63
Fruits not specified dried, fresh equivalent 3	5.9
Fruits not specified frozen, fresh equivalent	1.61
Oranges fresh, fresh equivalent 4	9.06
Orange juice, fresh equivalent	18.47
Lemons fresh, fresh equivalent	1.7
Lemon juice, fresh equivalent	3.43
Grapefruits fresh, fresh equivalent	1.11
Grapefruit juice, fresh equivalent	0.81
Limes fresh, fresh equivalent	0.68

Mandarins fresh, fresh equivalent	3.87
Other citrus fresh, fresh equivalent	0.03
Olives fresh, fresh equivalent	0.01
Apricots fresh, fresh equivalent	0.09
Apricots canned, fresh equivalent	0.02
Nectarines fresh, fresh equivalent	0.59
Figs fresh, fresh equivalent	0.39
Avocados fresh, fresh equivalent	1.83
Other fresh berries, fresh equivalent	1.12
Blueberries fresh, fresh equivalent	0.68
Blueberries canned, fresh equivalent	0.01
Blueberries frozen, fresh equivalent	1.54
Cherries fresh, fresh equivalent	0.68
Cherries frozen, fresh equivalent	0.4
Cranberries fresh, fresh equivalent	2.22
Grapes fresh, fresh equivalent	4.6
Grape juice, fresh equivalent	3.33
Melons, musk and cantaloupes fresh, fresh equivalent	2.51
Other fresh melons, fresh equivalent	1.76
Watermelons fresh, fresh equivalent	6.35
Wintermelons fresh, fresh equivalent	0.03
Peaches fresh, fresh equivalent	1.02
Peaches canned, fresh equivalent	0.66
Pears fresh, fresh equivalent	2.09
Pears canned, fresh equivalent	0.22
Plums total fresh, fresh equivalent	0.53
Raspberries frozen, fresh equivalent	0.39
Strawberries fresh, fresh equivalent	3.07
Strawberries canned, fresh equivalent	0.06
Strawberries frozen, fresh equivalent	0.77
Artichokes fresh, fresh equivalent	0.03
Asparagus fresh, fresh equivalent	0.6
Asparagus canned, fresh equivalent	0.35
Beans green and wax fresh, fresh equivalent	0.9
Beans green and wax canned, fresh equivalent	0.89
Beans green and wax frozen, fresh equivalent	0.32
Okra fresh, fresh equivalent	0.15
Beets fresh, fresh equivalent	0.92
Beets canned, fresh equivalent	0.3
Broccoli fresh, fresh equivalent	2.7
Broccoli frozen, fresh equivalent 5	0.96

Rappini fresh, fresh equivalent	0.18
Brussels sprouts fresh, fresh equivalent	0.23
Brussels sprouts frozen, fresh equivalent	0.09
Cabbage fresh, fresh equivalent 6	3.9
Chinese cabbage fresh, fresh equivalent	1.01
Kohlrabi fresh, fresh equivalent	0.97
Carrots fresh, fresh equivalent	7.52
Carrots canned, fresh equivalent	0.15
Carrots frozen, fresh equivalent	1.69
Other edible roots fresh, fresh equivalent	0.12
Vegetables not specified canned, fresh equivalent	4.37
Vegetables not specified frozen, fresh equivalent	1.28
Cauliflower fresh, fresh equivalent	2.23
Cauliflower frozen, fresh equivalent	0.14
Celery fresh, fresh equivalent	3.08
Corn fresh, fresh equivalent	3.04
Corn canned, fresh equivalent	2.27
Corn frozen, fresh equivalent	1.03
Corn flour and meal	0.34
Cucumbers fresh, fresh equivalent	3.15
Eggplants fresh, fresh equivalent	0.57
Leeks fresh, fresh equivalent	0.32
Lettuce fresh, fresh equivalent	9.6
Parsley fresh, fresh equivalent	0.32
Mushrooms fresh, fresh equivalent	1.74
Mushrooms canned, fresh equivalent	0.34
Garlic fresh, fresh equivalent	0.49
Onions and shallots fresh, fresh equivalent	9.07
Parsnips fresh, fresh equivalent	0.21
Peas fresh, fresh equivalent	0.21
Peas canned, fresh equivalent	0.4
Peas frozen, fresh equivalent	0.77
Peppers fresh, fresh equivalent	4.25
Potatoes chips, fresh equivalent	11.53
Potatoes frozen, fresh equivalent	12.36
Potatoes other processed, fresh equivalent	10.54
Potatoes total processed, fresh equivalent	34.42
Potatoes sweet, fresh equivalent	1.1
Potatoes white fresh, fresh equivalent [7, 8, 9]	22.27
Potatoes white fresh and processed, fresh equivalent [7, 8, 9]	51.42

Manioc fresh, fresh equivalent	0.1
Rice	6.86
Pumpkins and squash fresh, fresh equivalent	2.95
Radishes fresh, fresh equivalent	0.61
Rutabagas and turnips fresh, fresh equivalent	1.18
Spinach fresh, fresh equivalent	0.94
Spinach frozen, fresh equivalent	0.31
Tomatoes fresh, fresh equivalent	8.08
Tomatoes canned, fresh equivalent	6.24
Tomato juice, fresh equivalent	0.61
Tomatoes, pulp, paste and puree, fresh equivalent	14.9

(Statistics Canada, n.d.a)

Appendix 2. Nova Scotia Yield Data

Commodity	Average Yield (kg/hectare)
Wheat	5,000
Rye	2,910
Oats	2,800
Barley	3,700
Beans	2,800
Asparagus	1,400
Green beans	2,900
Beets	37,000
Broccoli	4,500
Brussels sprouts	5,900
Cabbage	21,900
Carrots	52,100
Cauliflower	12,400
Celery	1,300
Corn	4,500
Cucumber	9,700
Leeks	12,300
Lettuce	4,100
Onions	47,300
Parsnip	3,400
Peas	3,200
Peppers	9,300
Potatoes	13,716
Pumpkins and Squash	7,000
Radishes	3,200
Rutabaga and Turnip	26,300
Spinach	2,900
Tomatoes	23,600
Watermelon	4,500

Soybeans	2,800
Corn for grain	7,700
Corn fodder	40,830
Tame Hay	4,690

(Statistics Canada, n.d.h; Statistics Canada, n.d.d; Statistics Canada, n.d.e, Statistics Canada, n.d.j; Statistics Canada, n.d.k)

Appendix 3. Calorie Conversion Table

Original Food	Calories Consumed as Original Food (kcal/kg)	Local Food Equivalent	Consumption Needed as Local food (kg)
Oranges	3529.7	Apple	6.79
Lemons	5721.7		11.00
Grapefruits	723.2		1.39
Limes	117		0.23
Mandarins	201.4		0.39
Bananas	13946.3		26.82
Guavas and Mangoes	940.8		1.81
Kiwi	335.5		0.65
Papaya	176.3		0.34
Pineapples	2600		5.00
Dates	4192.5		8.06
Olive	14.5		0.03
Apricot	52.8		0.10
Nectarines	259.6		0.50
Fig	288.6		0.56
Musk and cantaloupe	853.4	Watermelon	2.84
Winter melons	3.9		0.01
Other fresh melons	563.2		1.88
Rice	8918	Potato	11.58
Manioc	160		0.21
Avocado	2928	Blueberries	5.14
Eggplants	142.5	Zucchini	0.84
Garlic	730.1	Onion	1.83
Kohlrabi	261.9	Cabbage	1.05
Okra	49.5	Green Beans	0.16
Parsley	115.2	Lettuce	0.77
Rappini	39.6	Broccoli	0.12
Artichokes	14.1	Asparagus	0.07

(USDA, 2017).

Appendix 5. Food Specific Assumptions and Methodology

Commodity	Assumption/ Methodology	Rationale
Rice	Assumed to be potatoes	Both foods considered simple carbohydrates
Milk Solids	All milk solids derived from dairy cows	Simplification purposes
Citrus Fruit	Assumed to be apples	Apples are produced widely in Nova Scotia and have similar growing characteristics to citrus fruits (grown on trees)
Other citrus fresh	Mass converted directly to apples	The citrus fruit was unspecified so a calorie conversion was impossible
Other fresh berries	Mass converted directly to blueberries	The berries were unspecified so a calorie conversion was impossible
Chinese Cabbage	Mass converted directly to cabbage	Extremely similar attributes
Musk and Cantaloupe	Caloric value of cantaloupe was used and converted to watermelon	Cantaloupe is far more common place than musk, and watermelon is the principal melon grown locally
Other fresh melons	Caloric intake for honeydew and casaba was used in conversion calculations	These were the two other melon types not specified in consumption data but listed on the USDA food site
Fruits not specified	Mass converted directly to Apples	Cheap and abundant and produced in large quantities in Nova Scotia
Other root vegetables	Mass converted directly to carrots	Carrots are the root vegetable produced in the largest quantity in Nova Scotia
Avocados	Assumed to be blueberries	Avocados are considered berries and blueberries are the berries produced in the largest quantity in Nova Scotia
Vegetables not specified	Mass converted directly to carrots	Carrots are easy to grow and are a vegetable produced in largest quantities in Nova Scotia
Cassava	Assumed to be potatoes	Both foods contain high levels of starch and are major sources of carbohydrates

Olives	Pickled or bottled green olives	Least brand specific olive data available on the USDA food composition database
Breakfast food	Assumed to be heat	Simplification purposes, as the majority of breakfast cereals are wheat based
Sugar	Assumed to be Maple sugar	Sugar content was looked at specifically, to ensure a baseline amongst all sugar types and allow for easy conversion to maple sugar
Turkey	Assumed to be chicken	Simplification Purposes, raised in similar growing conditions
Soy meal	Assumed to be Soy beans	Yield data available
Pig	Assumed diet was composed of 50% corn, 50% soy	Pigs diet is composed mainly of corn and soy, however they can vary dramatically. Simplified for calculation purposes
Chicken	Poultry by-product, poultry fat, fish meal, salt and limestone consumed in chicken diets were removed and other feed components were increased proportionately	Simplification Purposes
Hay	Assumed to be tame Hay	Hay yield data available
Dairy	Dry cow supplement, calf starter, chocolate, mineral premix and heifer grower not considered in diet	Simplification processes, due to lack of data
Watermelon	New Brunswick Yield data used	Nova Scotia yield data unavailable
Corn Meal	Assumed to be corn, given that moisture content remained constant and 100% of processing products are being used	Simplification Purposes, due to data availability
Apricots	Assumed to be apples	Although able to be grown in Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Fig	Assumed to be apples	Although able to be grown in

		Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Nectarines	Assumed to be apples	Although able to be grown in Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Kohlrabi	Assumed to be cabbage	Although able to be grown in Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Okra	Assumed to be green beans	Although able to be grown in Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Rappini	Assumed to be broccoli	Although able to be grown in Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Eggplant	Assumed to be zucchini	Although able to be grown in Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Artichoke	Assumed to be asparagus	Although able to be grown in Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Parsley	Assumed to be lettuce	Although able to be grown in Nova Scotia conditions, yield and production data were unavailable so a calorie conversion was conducted
Livestock	Assumed to be raised on a feedlot	Simplification purposes
Oils	Assumed to be derived from soy	Simplification purposes

Sheep	Assumed to be beef	Both animals possess similar reproductive cycles, thus the conversion was made for simplification purposes
Nuts	Assumed to be kidney beans	Both foods considered large sources of protein, therefore a protein conversion was done.

Appendix 4. Nova Scotia Production Data

Commodity	Produced (kg)	Area Used (hectares)
Apples	36,440,000	2,130
Blueberries	29,194,000	18,240
Cherries	27,000	14
Cranberries	967,000	127
Grapes	1,126,000	266
Honey	192,323	24,978
Peaches	119,000	30
Pears	330,000	61
Plums	41,000	20
Raspberries	70,000	42
Strawberries	1,286,000	289
Mushrooms	1,601,182	6

(Statistics Canada, n.d.f; Statistics Canada, n.d.g; Statistics Canada, n.d.i)