Food Miles:

Environmental Implications of Food Imports to Waterloo Region

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Executive Summary
The concept of “food miles” is used to describe the distance that food travels from the location where it is grown or raised to the location where it is consumed. This report documents the average distances travelled by imports of selected food items to Waterloo Region as well as the greenhouse gas (GHG) emissions associated with their transport.

Imports of 58 commonly eaten foods travel an average of 4,497 km to Waterloo Region. These imports account for 51,709 tonnes of GHG emissions annually, contributing to climate change and air quality, which both have an effect on human health.

Since all of the studied food items could be grown or raised in Waterloo Region, a significant opportunity exists to reduce our contribution to global climate change and air pollution by replacing imports of the studied food items with food items sourced from Waterloo Region or South-western Ontario. Replacing all the studied food items with products of South-western Ontario would produce an annual reduction in GHG emissions of 49,485 tonnes, equivalent to taking 16,191 cars off our roads. Strategies to strengthen to the local food system and make purchasing local food more convenient for consumers have the potential to reduce the environmental impact of food miles in Waterloo Region.

1. Introduction

This report was produced as part of a series of studies commissioned by Region of Waterloo Public Health in 2005 to document the state of Waterloo Region's food system. Its findings were summarized along with those of other related studies in *Toward a Healthy Community Food System for Waterloo Region* (ROWPH, 2005b). This latter report is a component study of the Regional Growth Management Strategy, which sets out goals for managing projected population growth for the Region over the next forty years.

For the better part of human history until several decades ago, most people ate food that came from local sources. However, a combination of developments, including advances in food processing technology, economies of scale in the food industry, and relatively cheap transportation, has created a situation today where much of the food we eat travels thousands of kilometres before ending up on our plates (Halweil, 2002, p.17).

The concept of "food miles" – the distance that food items travel from the location where they are grown or raised to the location where they are consumed – has received an increasing amount of attention over the last decade. Most literature on the issue has sought to make a correlation between the distances traveled by food items and the greenhouse gases (GHG) emitted in their transport. Greenhouse gases are emitted through the burning of fossil fuels, and affect air quality and global climate change, which have an effect on human health.

This report focuses on the average distances travelled by imports of selected food items to Waterloo Region and the GHG emissions associated with their transport.

2. Background

The term "food miles" was first coined in a 1994 report by a British non-profit organization now known as Sustain UK (DEFRA, p.2). In North America, the most widely-cited study on food miles continues to be the Leopold Center for Sustainable Agriculture's report *Food, Fuel, and Freeways* (Pirog et al., 2001). The authors of the Leopold Center report were able to access arrival data for the Chicago Food Terminal which specified the origin of all food items passing through the terminal. They found that food items traveled on average 1,518 miles (approx. 2,429 km) to get to Iowa destinations in 1998, a 22% increase over 1981. This average distance was 33 times greater than the 45-mile average distance traveled by food items in a local farm-to-institution program in Iowa. The food items sourced from the Terminal used 4 to 17 times more fuel and produced 5 to 17 times more GHG emissions than the locally-sourced ones.

Canadian food miles studies have been unable to replicate the Leopold Center's methodology due to an absence of comprehensive food terminal arrivals data. A study by Toronto non-profit organization Foodshare (Bentley, 2005) took the straightforward approach of purchasing the same dinner ingredients at a grocery store and a farmers' market, reading product labels to identify source locations, and contacting producers to identify the mode of transport. The study found that the local food items traveled an average of 101km, versus 5,364km for the imported items. The imported food items created 100 times more greenhouse gas emissions than the local ones.

The Lifecycles Project (2004), based in Victoria, B.C., created an on-line database of food imports to British Columbia. Rather than using food labels to trace origins of specific items, it used import data tracked by Customs and Immigration Canada to generate average distances of all imports of selected food items. Using this approach, the Lifecycles *Good Food Directory* website is able to instantly call up the average food miles for imports of selected food items, and then compare the greenhouse gas emissions created by the imports to locally-sourced versions of the same food items. This report makes use of Lifecycles' methodology, with some minor variations.

3. Study Methodology

The objective of this study was to determine the average distances traveled by imports of selected food items to Waterloo Region and the GHG emissions associated with their transport. Sections 3.1 to 3.11 describe the methodology used to arrive at this report's findings.

3.1. Calculating WASD and WAER

This study relies largely on two calculations to assess the distances traveled by food and the air emissions associated with the transport: Weighted Average Source Distance (WASD) and Weighted Average Emissions Ratio (WAER). The WASD is the average distance that a food travels from where it is produced to where it is consumed. The formula to calculate it was developed by Annika Carlsson-Kanyama (1997), and was used in three other studies cited above (Pirog et al., 2001, Lifecycles, 2004, and Bentley, 2005).

$$\text{Weighted Average Source Distance (WASD) (km)} = \frac{\sum(v * d)}{\sum v}$$

where:

$\sum$ = sum of
v = value ($) of imports from each location of production origin
d = distance (km) from each location of production origin to the point of consumption

The WAER is the average amount of GHG emissions (in kg) created by each kg of a food item in its travel from point of production to consumption. The formula was created by Lifecyles (2004).

$$\text{Weighted Average Emissions Ratio (WAER)} = \frac{\sum (v * d * e)}{\sum v}$$

where:

v = value ($) of imports from each location of production origin
d = distance (km) from each location of production origin to the point of consumption
e = greenhouse gas (GHG) emission level (g/T-km) for mode of transport (see section 3.5)

The WASD and WAER findings for all selected food items can be found in columns A and B of Appendix 1.

3.2. Food Product Selection

The study selected a variety of food items which met the following criteria:

a) could be grown or raised locally;
b) being studied by the Redundant Trade (ROWPH 2005c), Optimal Nutrition Environment (ROWPH, 2005a), and/or Food Flow studies (HCA, 2005)[1];
c) have accessible and reliable import data;
d) reflect a mixture of fresh and preserved products; and
e) are representative of the basket of items that Waterloo Region consumers actually eat.[2]

Based on these criteria, a list of thirty-one product categories was identified, as shown in Appendix 2. The list of food items was expanded during the study to include more specific variations of the food items (for example, garlic was expanded to fresh, dried, and powdered), resulting a total of 58 food items studied.

3.3. Food Import Data

Import data for each of the food items was obtained from Industry Canada's *Strategis* website (2005), which enables users to generate reports of internationally traded commodities categorized by 6-digit "Harmonized System" (HS) codes. The HS is used by governments for categorizing all internationally-traded commodities. Data reports were generated for the dollar value[3] of the total imports to Ontario[4] of each food item for five years (2000-2004). Two separate reports were generated for each food item: one detailing imports from all countries, and one detailing imports from all the United States of America. These were exported as comma-separated value (.csv) files and then imported into Microsoft Excel.

Data for some of the selected food items were not available on the Strategis website, and were obtained through a special request made to Agriculture and Agri-Food Canada (AAFC, 2005). AAFC was able to provide four years (2001-2004) of import data to Ontario for 10-digit HS codes (the extra digits in HS codes provide additional detail). All the HS codes used for this study are listed in Column B of Appendix 2.

A sum of the five-year (or four-year, as applicable) import value was calculated for each source country/state for each selected food for use in the WASD and WAER calculations.

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[1] These studies were all commissioned (along with this one) by Region of Waterloo Public Health in 2005 as part of a report on the current food system in Waterloo Region (ROWPH, 2005b).
[2] This study included all fifteen of the foods analysed by the *Food Flow Analysis Study* (HCA, 2005), which used a rigorous process using national food consumption data from Statistics Canada to arrive at a basket of food items representative of actual food consumption.
[3] All values were in Canadian dollars, unadjusted for inflation.
[4] Import data specifies the destination province, but not region or city. For the purposes of this study, the weighted average value of imports to Ontario was assumed to be the same as that for Waterloo Region. So if 27% of imports of canned tomatoes to Ontario came from Italy, the study assumed that 27% of Waterloo Region's imports also came from Italy.

3.4. Distances from Sources of Production Origin

All distances were calculated from state and country capitals, or the biggest port or airport if this was not in the same city as the capital. All travel from North American sources was assumed to be by truck. Distances from American states to Waterloo were obtained from www.mapblast.com, which measures distance by road. The distance from Mexico was calculated as the average distance to Waterloo from the capitals of the top four agricultural states in Mexico – Jalisco, Guanajuato, Puebla, Sinaloa – and Mexico City.

For imports from outside of North America, the study assumed that fresh or perishable products travelled by air, and store-able or preserved products travelled by ship. All overseas transport mode assumptions are listed in Column H of Appendix 2. Air distances to Toronto were calculated using www.indo.com/distance/index.html, to which the distance from Toronto to Waterloo was added, which was assumed to be by truck. Marine distances to New York[5] were calculated using www.maritimechain.com, to which the distance from New York to Waterloo was added, which was assumed to be by truck. Where country of origin had no shipping port, the air distance from the closest port or capital city was used. If the proportion of imports from a country was less than 0.5% of the total amount of imports of a food, the data was excluded.

3.5. Emissions Data by Mode of Transport

Table A: GHG Emissions by Transport Mode

Transport Mode	GHG emission levels (g per tonne-kilometre)
Air	1,101.0
Marine	130.3
Rail	21.2
Truck	269.9

Figures for greenhouse (GHG) emissions by mode of transport (the "e" variable in the formula to calculate WAER) were obtained from Environment Canada (2002). The levels, shown in Table A, represent the average amount of greenhouse gas emissions emitted by the four different transport modes in Canada in the years 1990-1999. The GHG emissions are mostly carbon dioxide (CO_2), but also include nitrous oxide (N_2O) and methane (CH_4) converted into equivalent units of CO_2 based on their global warming potential.

It should be noted that the figures in Table A are *average* emissions for these modes of transport in Canada for a time period (1990-1999) ending immediately prior to the data on imports of the selected food items (2000-2004). It is likely that newer, more efficient engine technology has reduced emissions somewhat since the data collection period. Furthermore, actual specific GHG emissions from transport will vary for each shipment of the imported food items, depending on engine efficiency, refrigeration,[6] load factor efficiency,[7] and possibly other factors. However, the Environment Canada emissions ratios represent the most recent available data of GHG emissions by transport mode in Canada (McKibbon, 2005).

[5] A representative of the National Grocer regional distribution plant in Cambridge stated that all products imported by ship arrived at New Jersey and were then trucked from there.
[6] Refrigeration adds to the transport-related emissions, and is required for the transport of most fresh food items.
[7] For example, a half-full truck will create half the emissions per tonne-km shipped compared to the same truck with a full load.

3.6. Food Consumption Data

In order to estimate the impact of Waterloo Region's food imports, the study needed to establish estimates of actual consumption of the food items by Waterloo Region residents. Two sources of food consumption data were examined for this purpose. The first source was Statistics Canada's Food Expenditure survey (2003), which gives data on per capita weekly expenditures on a variety of food items in litres or kilograms. This is national data which has been aggregated to the Ontario and mid-urban population (250,000-499,999) levels. Multiplying the per capita numbers by the population of Waterloo Region (477,400 in 2003) generates a number for the amount of these food items purchased in Waterloo Region. This source had data in kilograms for less than half of the selected food items.

The second source was Supply and Disposition data, also from Statistics Canada (2005). This source gives aggregate national supply numbers for most of the selected food items, including the total amount of imports, exports, domestic production, and amounts used for manufacturing or lost to waste. These numbers generate a "disappearance per person" number, which was then multiplied by the population of Waterloo Region to generate a number in kilograms representing the total amount of that food disappeared. The data for each selected food item can be found in Column E of Appendix 1.

The food disappearance data is preferred as a measure of domestic consumption over the food expenditure data for two reasons. First, data exists for more of the selected food items. Second, although the food expenditure data may be a more accurate reflection of food purchased by consumers, disappearance data reflects the total amount of each food brought into the country, whether it is eaten or discarded. This is more relevant when analyzing food miles.

For the purposes of this report, food consumption in Waterloo Region was assumed to be the same as the national average.

3.7. Imports as Percentage of Domestic Consumption

The food miles data in this report measure only imports of the selected food items. Therefore, it is important to consider the proportion that imports make up of domestic consumption. For example, imports of concentrated or sweetened milk to Waterloo Region have a very high WASD (15,701 km – because they come mostly from New Zealand) and WAER (2.168:1 – meaning they produce over twice their weight in GHG emissions). However, we import less than 12% of the concentrated or sweetened milk consumed in Canada, making the impact of imports much less than if imports were to be a higher proportion.

To ensure that this context was provided, the study looked at the proportion that imports make up of total domestic consumption for each of the selected food items. To calculate this, the study used supply and disposition data from Statistics Canada (2005), taking the total imports as a percentage of the net supply available for consumption. Fifteen-year (1989-2003) totals were used in making the calculation, using the following formula:

$$\text{Imports as \% of Domestic Consumption} = \frac{\sum \text{Imports (1989-2003)}}{\sum \text{Net Supply (1989-2003)}}$$

Data were not available for all fifteen years for all selected food items: when they were not, the calculation was made for the years for which data were available. For the purposes of this report, the proportion of food consumption in Waterloo Region made up by imports was assumed to be the same as the national average. The proportions can be found in Column F of Appendix 1.

3.8. Total GHG Emissions from Imports of Selected Food Items

The study used following formula to calculate how many tonnes of GHG emissions are created by imports of each selected food:

GHG emissions = WAER * c * i

where:
WAER = the average amount (kg) of GHGs emitted for each kg of a food item imported
c = the total consumption of the food item in Waterloo Region (kg)
i = the proportion that imports make up of domestic consumption (%)

For example, imports of fresh tomatoes to Waterloo Region have a WAER of 1.095:1 kg. Disappearance data indicate that 3,559,095 kg of fresh tomatoes are consumed each year in the Region, and that 72% of these tomatoes are imported. Therefore, we can calculate that the GHG emissions created by imports of tomatoes to Waterloo Region each year are equal to 1.095 * 3,559,085 * 0.72 = 2,806,077 kg, or 2,806 tonnes. Data for total GHG emissions for all selected foods are in Column G of Appendix 1.

3.9. Comparisons to Vehicle Emissions

To make the GHG emissions numbers more universally comprehensible, a calculation was made to compare the emissions created by the imported food items to the emissions created by personal automobiles. Fuel economy data for a typical compact vehicle was obtained from a calculator on the National Resources Canada website (2005). An average annual driving distance of 18,000km (based on CAA, 2005) was inputted into the calculator, and the average ratio of city to highway driving was assumed to be 50-50. The fuel economy number was then used to calculate GHG emissions per litre of fuel by referring to Environment Canada's *Greenhouse Gas Inventory* (2004), which reports on the GHG emissions per litre of fuel burned in light-duty gasoline-powered vehicles. Using all this information, the study calculated that a 2004 Toyota Corolla generates 3.06 tonnes of GHG emissions per year, which was used to generate figures for the equivalent number of cars for imports of each selected food. These figures can be found in Column H of Appendix 1.

3.10. Comparisons to Local Food Items

Because all the food items selected for the study could be grown or raised in Waterloo Region (WR), it is reasonable to compare the GHG emissions of the imports to the same food items sourced from WR farms. The distance for food from WR farms to consumers was assumed to be 30km (approximately equal to the distance from the Region's border to the centre of the closest

city). Transport was assumed to be by truck. Using these calculations, the WAER for WR-sourced food items was found to be 0.008:1 kg (i.e. each kg of local food leads to just over 8 g of GHG emissions). This figure can be used to calculate a comparison for GHG emissions between imported and WR-sourced food items (see data in Column D of Appendix 1).

Another theoretical comparison group was set up to compare the emissions of imports to a South-western Ontario (SW-Ont) food system. In this food system, food items would be sourced from an average distance of 250 km away from Waterloo Region, with travel by truck. Using these assumptions, the WAER for food items sourced from a South-western Ontario region would be 0.067:1 kg (i.e. each kg of SW-Ont food leads to just over 67 g of GHG emissions).

3.11. Comparisons to Total Household Emissions

In order to determine the significance of the GHG emissions from imports of the selected food items to the Region, an estimate was made of the total personal GHG emissions from the Region. Canada's One Tonne Challenge (2005) reports that each Canadian household is responsible for over 5 tonnes of GHG emissions annually. Combining the 5 tonne figure with the total number of households in the Region in 2004 (176,160), we can estimate that Waterloo Region households create 880,800 tonnes of GHG emissions annually. This figure was then compared to the total GHG emissions resulting from imports of the selected food items.

4. Study Limitations

The WASD figures calculated by this study are measures of average source locations of *selected imports*. They do not take into account food items sourced from other municipalities or provinces in Canada. Food miles numbers which included domestic sources of the selected food items would almost certainly be lower. At the same time, it should be noted that many domestic Canadian food items may travel significant distances (P.E.I. potatoes, for example, would travel 1,800 km to Waterloo).

While representative of commonly-eaten food items, the average and median WASD figures calculated by this study are not measures of all food items consumed in Waterloo Region. Thus they cannot be compared directly to the often-cited 1,518 mile (2,429 km) number from Iowa's Leopold Center (Pirog et al, 2001), which describes *all* food items from *all* source locations, including domestic.

A recent report by the United Kingdom's Department of the Environment, Food, and Rural Affairs suggests contextualizing food miles data with additional information about the costs of food transport. It suggests collecting data on food transport within urban areas separately from data on food transport in heavy goods vehicles (HGVs). It argues that urban food transport has a much greater impact on traffic congestion and collisions, and that the impact of air pollution is more apparent in urban areas. HGV transport, on the other hand, tends to be along inter-city highways and has a higher contribution to road infrastructure deterioration and air pollution (DEFRA, 2005, pp. iii-vi). Collecting separate urban food transport data would also take into account the distances that consumers drive to supermarkets, which according to the UK report has increased over the years as consumers have moved from making frequent visits to local shops to weekly visits to large out-of-town supermarkets (ibid, p. vii). This study did not collect data on urban versus HGV food transport, but this may be a suitable area for future research.

This study does not take into account any issues to do with energy used in agricultural production or in food processing: it only measures the emissions associated with fuel consumption of the relevant transport mode. Due to a shorter growing season in Ontario, some imported food items may produce fewer GHG emissions than a locally grown or produced product. For example, British tomatoes grown in greenhouses have been demonstrated to cause twice as much CO_2 as tomatoes imported by truck from Spain (ibid, pp. 66-67). Any efforts at replacing imports with local food items should take the energy trade-offs specific to each food item into account.

5. Findings

A table with all data from the 58 studied food items can be found in Appendix 1. Table B lists the top ten imported food item contributors to GHG emissions in Waterloo Region.

Table B: Top Ten Imported Food Item Contributors to Greenhouse Gas (GHG) Emissions, Waterloo Region

Food Item	Annual GHG Emissions from Waterloo Region Imports (tonnes)	Annual Equivalent in # of cars on Road	# of Times more Emissions than Local Product	WASD (km)	WAER (kg of GHG / kg of Food Item)
1. Beef	15,729	5,146.2	667.3	5,770	5.403:1
2. Pears - fresh	5,016	1,641.0	561.7	6,054	4.548:1
3. Lettuce (incl. head and leaf)	4,709	1,540.7	125.0	3,726	1.012:1
4. Tomatoes - fresh	2,806	918.1	135.2	2,800	1.095:1
5. Potatoes - fresh	2,504	819.2	94.4	2,832	0.764:1
6. Peppers - bell, fresh	2,381	778.9	229.2	3,281	1.856:1
7. Apples - fresh	1,924	629.6	148.5	5,925	1.202:1
8. Onions	1,771	579.6	115.6	3,570	0.936:1
9. Cheese	1,665	544.7	687.4	5,278	5.566:1
10. Carrots	1,489	487.3	129.1	3,936	1.045:1
	Average (all studied products)			**4,497**	**1.301:1**
	Median (all studied products)			**3,651**	**0.991:1**
Total (all studied products)	**51,709**	**16,918**			

WASD = the average distance traveled by imports of the food item to Waterloo Region
WAER = the average amount (kg) of GHGs emitted for each kg of a food item imported

Imports of the 58 studied food items into Waterloo Region generate 51,709 tonnes of GHG emissions annually, which is equivalent to the emissions produced by 16,918 cars being driven for one year. This represents 5.9% of the GHG emissions generated by households in the Region.

Imports of these food items travel an average of 4,497 km (median of 3,651 km) to Waterloo Region, and generate an average of 1.3 kg (median of 1.0 kg) of GHG emissions for every kilogram of food imported.

In contrast, the same food items if sourced from Waterloo Region (WR) would travel 30 km from farm to plate and would generate .008 kg of GHG emissions for every kilogram consumed. If they were sourced from a South-western Ontario (SW-Ont) regional food system, they would travel an average of 250 km and generate 0.067 kg of GHG emissions. Imports of the studied food items travel on average 150 times further than the same food items would if sourced in Waterloo Region, and 18 times further than if they were sourced from South-western Ontario. Imports create on average 161 times more GHG emissions than if sourced in Waterloo Region, or 19 times more emissions than if sourced from South-western Ontario.

Figures 1 and 2 show details for two imported food items to Waterloo Region.

Figure 1: Beef Imports to Waterloo Region, 2001-2004

WASD: 5,770 km WAER: 5.403:1
Overseas transport assumption: air

Imported beef travels 5,770 km on average to Waterloo Region, and its transport produces more than five times its own weight in GHG emissions.

Major Source Locations	Proportion of All Imports
Colorado (2,321km)	21%
Kansas (1,649 km)	16%
Australia (15,935 km)	15%
New Zealand (14,254km)	12%
Nebraska (1,545 km)	9%

Beef sourced from Waterloo Region produces 667 fewer GHG emissions than imported beef.

Figure 2: Imports of Canned Tomatoes to Waterloo Region, 2001-2004

WASD: 5,244 km WAER: 1.067:1
Overseas transport assumption: marine

Imported tomatoes travel 5,244 km on average to Waterloo Region, and their transport produces slightly more than their own weight in GHG emissions.

Major Source Locations	Proportion of All Imports
California (3,994 km)	58%
Italy (9,445 km)	27%
Ohio (600 km)	4%
Indiana (781 km)	3%

Tomatoes sourced from Leamington (a prime tomato-growing area) produce 14 times fewer GHG emissions than imported tomatoes. Tomatoes from Waterloo Region produce 132 times fewer GHG emissions.

If all 36 million kg of imports of the 58 studied food items were to be obtained from South-western Ontario or Waterloo Region sources rather than imported, 49,485 to 51,442 tonnes of GHG emissions would be reduced annually. This reduction would be the equivalent of removing 16,191to 16,831 cars from Regional roads annually. If the imported food items were replaced completely by food items from SW-Ont or WR sources, each household in Waterloo Region could reduce its GHG emissions by 0.281 to 0.292 tonnes.

6. Discussion

The chemicals emitted by the burning of fossil fuels – which are referred to in this report as GHG emissions – have other effects in addition to their contribution to global climate change. Fossil fuel combustion creates a variety of chemicals[8] which contribute to environmental problems such as acid rain, smog, and toxic air pollution. One might argue that food imports do not affect these environmental issues in Waterloo Region, since most of the emissions would be

[8] The chemicals include nitrogen dioxide (NO_2), sulfure dioxide (SO_2), volatile organic compounds (VOCs), carbon monoxide, (CO), particulate matter (PM_{10}), nitrous oxide (N_2O), methane (CH_4), carbon dioxide (CO_2), and other toxic air emissions.

emitted on their global journey to Waterloo Region. But the GHG emissions contribute to the global climate change problem no matter where they were emitted. Further, these 51,709 tonnes of annual GHG emissions are the result of demand by Waterloo Region consumers, and thus are within our ability to control.

Since all the selected food items could be grown in Waterloo Region, it would be feasible to suggest replacing imports of the studied food items with products sourced in Waterloo Region or South-western Ontario as a means of mitigating the environmental impacts of distant food travel. Although climate conditions limit the potential for growing fresh produce year-round in South-western Ontario, most of the selected food products could be canned, stored, or processed for year-round consumption. Already, some of the imports of fresh produce come at peak local harvest time (ROWPH, 2005c): eliminating this redundant trade would have environmental benefits.

This study found the GHG emissions reductions associated with food items sourced from South-western Ontario to be almost as great as for ones sourced from Waterloo Region. Since other factors make sourcing food from SW-Ont more feasible in many cases, a strategy to replace imports with SW-Ont products may be more reasonable than one focusing exclusively on Waterloo Region. This study defined SW-Ont as a 250 km radius from WR, which includes locations as far as Chatham, Orillia, or Peterborough, as well as the Greater Toronto Area. Though Waterloo Region soils could grow all of the studied food items, in some cases better growing conditions exist elsewhere in the SW-Ont foodshed (e.g. tomatoes in Leamington area, cherries in Niagara Region). Further, a significant amount of food available to WR consumers already comes from Ontario sources outside WR (HCA, 2005, and ROWPH, 2005c), which means the economic infrastructure (i.e. food processing and distribution) is already in place. It may be easier to expand existing infrastructure to replace imports than to create new ones exclusively for Waterloo Region. Economies of scale may also make it more feasible, at least in the short-term, to target a SW-Ont versus WR market.

Canada's One Tonne Challenge asks Canadians to reduce their personal GHG emissions by 20%, by reducing GHG emissions from the average five tonnes per household per year to four. Though the total GHG emissions of the studied food items are just 5.9% of total household GHG emissions, replacing just the studied food items with ones sourced in SW-Ont would reduce household emissions by 0.281 tonnes per year, which would provide more than one quarter of the change necessary for households to meet the One Tonne Challenge.

To a certain extent, replacing consumption of imports of the studied foods with local ones is possible on a personal level. However, barriers exist to buying local food, including perceptions that it is unavailable, consumer inability to identify it, and acceptance of preserved foods in the off-season (ROWPH, 2004). Replacing food imports will require policy changes that make local food consumption more convenient to consumers. ROWPH's *Toward a Healthy Community Food System* (2005) suggested several possible strategies for moving towards that goal, including increasing urban agriculture projects, expanding farmers' markets, establishing farm to institution programs, and encouraging the local food processing and distribution sectors, among others. A combination of these strategies has potential for reducing the environmental impact of food miles in Waterloo Region.

7. Conclusions

This study demonstrated that imports to Waterloo Region of 58 commonly-eaten food items travel 4,497 km on average, and account for 51,709 tonnes of GHG emissions annually. Since all of the studied food items could be grown or raised in Waterloo Region, a significant opportunity exists to reduce our contribution to global climate change and air pollution by replacing imports of the studied food items with food items sourced from Waterloo Region or South-western Ontario. Replacing all the studied food items with products of South-western Ontario would produce an annual reduction in GHG emissions of 49,485 tonnes, equivalent to taking 16,191 cars off our roads. Strategies to strengthen to the local food system and make purchasing local food more convenient for consumers have the potential to reduce the environmental impact of food miles in Waterloo Region.

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Appendix 1: Food Miles Data for all Studied Food items, Waterloo Region, 2005

	A	B	C	D	E	F	G	H
#	**Food Item**	**WASD (km)**	**WAER (kg of GHG emissions per kg of food item)**	**# of Times more Emissions than Waterloo Region Product**	**Amount Disappeared in Waterloo Region in 2003 (kg)**	**Imports as % of Domestic Consumption**	**Annual GHG Emissions from Waterloo Region Imports (tonnes)**	**Equivalent in # of cars on Road**
1	Apple Juice	10,237	1.439:1	177.7	3,523,212	28%	1,422	465.4
	Apples - dried	4,121	0.992:1	122.5	28,017	101%	28	9.2
	Apples - fresh	5,925	1.202:1	148.5	4,995,088	32%	1,924	629.6
2	Barley	2,952	0.740:1	91.4	43,800	no data	–	–
3	Beans, Baked	4,554	0.787:1	97.2	645,009	24%	124	40.4
	Beans, White	1,802	0.918:1	113.4	no data	–	–	–
4	Beef	5,770	5.403:1	667.3	11,614,758	25%	15,729	5,146.2
	Beef/Pork Wieners	1,038	0.289:1	35.7	no data	–	–	–
5	Blueberries - dried	1,486	0.400:1	49.4	no data	–	–	–
	Blueberries - fresh	4,494	3.646:1	450.3	250,750	75%	686	224.3
	Blueberries - frozen	825	0.173:1	21.4	219,604	*36%	14	4.5
6	Breakfast Cereals	1,613	0.407:1	50.3	2,544,542	*18%	190	62.2
7	Broccoli	3,651	0.991:1	122.4	1,354,644	81%	1,089	356.2
8	Cabbage	3,623	1.001:1	123.6	1,971,238	23%	463	151.5
9	Carrots	3,936	1.045:1	129.1	3,902,385	37%	1,489	487.3
10	Cheese	5,278	5.566:1	687.4	4,947,592	6%	1,665	544.7
11	Cherries - fresh	4,209	1.444:1	178.3	289,855	70%	295	96.4
	Cherries - prepared	1,943	0.420:1	51.9	no data	–	–	–
12	Chicken	2,918	0.911:1	112.5	**14,347,740	10%	1,242	406.5
13	Corn (Sweet) - fresh	678	0.243:1	30.0	1,502,709	34%	125	40.8
	Corn (Sweet) - frozen	2,285	0.559:1	69.0	448,756	*10%	25	8.1
	Corn (Sweet) - preserved	2,396	0.450:1	55.6	682,682	*12%	37	12.2
14	Garlic - dehydrated (powders)	6,750	1.198:1	148.0	no data	–	–	–
	Garlic - dried	4,701	1.079:1	133.3	no data	–	–	–
	Garlic - fresh	12,539	1.899:1	234.5	172,879	*102%	335	109.7
15	Lettuce (incl. head and leaf)	3,726	1.012:1	125.0	5,490,298	85%	4,709	1540.7
16	Milk/Cream - con. or swt.	15,701	2.168:1	267.8	865,906	12%	221	72.4
	Milk/Cream - fresh	2,778	2.681:1	331.1	41,457,671	0%	0	0.0
17	Mushrooms - dried	14,923	2.069:1	255.5	no data	–	–	–
	Mushrooms - fresh	1,697	1.359:1	167.8	535,703	12%	91	29.6
	Mushrooms - pres/prep	16,655	2.290:1	282.8	348,502	*65%	521	170.5

	A	B	C	D	E	F	G	H
#	**Food Item**	**WASD (km)**	**WAER (kg of GHG emissions per kg of food item)**	**# of Times more Emissions than Waterloo Region Product**	**Amount Disappeared in Waterloo Region in 2003 (kg)**	**Imports as % of Domestic Consumption**	**Annual GHG Emissions from Waterloo Region Imports (tonnes)**	**Equivalent in # of cars on Road**
18	Oats/Oatmeal	2,404	0.462:1	57.1	1,969,790	13%	118	38.6
19	Onions	3,570	0.936:1	115.6	3,604,128	53%	1,771	579.6
20	Peanuts - prepared	3,653	0.637:1	78.7	no data	–	–	–
	Peauts in shell	8,769	1.325:1	163.6	***355,858	*100%	471	154.3
	Peauts, shelled	4,871	0.837:1	103.4	***131,106	*100%	110	35.9
21	Pears - fresh	6,054	4.548:1	561.7	1,216,355	91%	5,016	1641.0
	Pears - preserved	9,433	1.481:1	182.9	176,638	*60%	157	51.5
22	Peas - canned	5,317	0.858:1	106.0	319,858	*5%	13	4.1
	Peas - dried	4,444	0.980:1	121.0	679,367	24%	162	53.0
	Peas - fresh	4,278	3.505:1	432.9	110,043	81%	312	101.9
	Peas - frozen	2,942	0.591:1	73.0	572,880	*7%	25	8.1
23	Peppers - bell, fresh	3,281	1.856:1	229.2	1,568,535	82%	2,381	778.9
24	Pork	1,422	0.499:1	61.6	9,116,375	6%	290	94.7
	Pork (Ham)	1,527	0.771:1	95.2	no data	–	–	–
25	Potatoes - fresh	2,832	0.764:1	94.4	16,460,752	20%	2,504	819.2
	Potatoes - frozen	2,751	0.681:1	84.1	3,547,082	8%	192	62.7
26	Pumpkins/ Squash	2,287	0.502:1	62.0	1,138,044	42%	237	77.6
27	Soda Biscuits	2,775	0.488:1	60.2	no data	–	–	–
28	Spinach - fresh	3,378	0.973:1	120.2	415,600	98%	398	130.1
	Spinach - frozen	1,948	0.448:1	55.3	64,751	*101%	29	9.6
29	Strawberries - fresh	3,756	1.061:1	131.0	1,130,618	69%	825	269.9
	Strawberries - frozen	4,053	0.953:1	117.7	253,022	*71%	171	56.1
	Strawberry jam	6,505	1.020:1	126.0	no data	–	–	–
30	Tomato sauces	2,083	0.527:1	65.1	1,365,364	*64%	462	151.2
	Tomatoes - canned	5,244	1.067:1	131.8	1,842,764	*42%	826	270.2
	Tomatoes - fresh	2,800	1.095:1	135.2	3,559,085	72%	2,806	918.1
31	Yogurt	1,533	0.995:1	122.9	2,795,907	0%	9	3.1
	Average:	**4,497**	**1.301:1**					
	Median:	**3,651**	**0.991:1**			**Total:**	**51,709**	**16,918**

*percentages were generated using incomplete data
**figure includes weight of all chicken carcasses: data on retail weight was unavailable
***figure calculated using national consumption data because disappearance data was unavailable

Appendix 2: Data Sources, Selection Criteria, and Transportation Assumptions for Studied Food Items

	A	B	C	D	E	F	G	H
	Food	**Detail**	**HS CODE**	**Local Capability?**	**studied by Food Flow (HCA, 2005)?**	**studied by ONE (ROWPH 2005a)?**	**studied by RT (ROWPH 2005c)?**	**Overseas Transport Mode Assumption**
1	1. Apple Juice	juice, unfermented	200970	YES	YES (juice, fresh)	YES	YES	marine
		juice, brix value <20	200971					
		juice, brix value 20+	200979					
	2. Apples	dried	081330					marine
	3. Apples	fresh	080810					marine
2	4. Barley	barley	100300	YES	NO	YES	NO	marine
		barley - rolled or flaked grains	110411					
		barley -hulled, pearled, sliced or kibbled	110421					
3	5. Baked Beans	shelled, baked, prepr/presvd o/t by vinegar, acetic acid or sugar, not frozen	2005519010	YES	NO	YES (white beans)	NO	marine
	6. White Beans	Navy/white pea beans, seed, dried, shelled, w/n skinned	0713331010	YES	NO	YES	NO	marine
		Navy /white pea beans, except seeds, dried, shelled, w/n or not skinned or split	0713339910					
4	7. Beef	carcasses and half-carcasses, fresh or chilled	020110	YES	YES (ground beef, beef wieners)	NO	NO	air
		cuts with bone in, fresh or chilled	020120					
		boneless cuts, fresh or chilled	020130					
		carcasses and half-carcasses, frozen	020210					
		cuts with bone in, frozen	020220					
		boneless cuts, frozen	020230					
		edible offal, fresh or chilled	020610					
	8. Beef/Pork Wieners	Pork sausages	1601009010	YES	YES (beef wieners)	NO	NO	air
		Wieners or frankfurters, nes	1601009092					
		Sausages, fresh, chilled or frozen, nes	1601009093					
		Sausages, cured, nes	1601009094					
		Sausages and similar products of meat, meat offal or blood, nes	1601009099					
5	9. Blueberries, frozen	pulp, frozen, uncooked/steamed/boiled in water, sweet/not	0811909011	YES (berries)	NO	YES (berries)	NO	marine
		wild, o/t pulp, frozen, uncooked/steamed/boiled in water, sweet/not	0811909012					

	A	B	C	D	E	F	G	H
	Food	**Detail**	**HS CODE**	**Local Capability?**	**studied by Food Flow (HCA, 2005)?**	**studied by ONE (ROWPH 2005a)?**	**studied by RT (ROWPH 2005c)?**	**Overseas Transport Mode Assumption**
		cultivated, o/t pulp, frozen, uncooked/ steamed/ boiled, sweet/not	0811909013					
	10. Blueberries, dried	wild, dried	0813400010					marine
	11. Blueberries, fresh	wild, fresh, in their natural state	0810401021					air
		cultivated, fresh, in their natural state	0810401022					
		wild, (except pulp), in air-tight containers	2008999032					
6	12. Breakfast Cereals	prepared foods obtained from unroasted cereal flakes	190420	YES	YES (corn flakes)	NO	NO	marine
		prepared foods obtained from the swelling or roasting of cereals	190410					
		cereals (except corn) in grain form, pre-cooked or otherwise prepared	190490					
7	13. Broccoli	for processing, fresh or chilled	0704901000	YES	NO	YES	NO	air
		fresh or chilled, period specified by minister	0704902100					
		fresh or chilled	0704902900					
8	14. Cabbage	except chinese, fresh or chilled, period specified by minister	0704903100	YES	NO	YES	NO	marine
		except chinese, fresh or chilled	0704903900					
		chinese or chinese lettuce, fr or chd, period specified by minister	0704904100					
		chinese or chinese lettuce, fresh or chilled, nes	0704904900					
9	15. Carrots	Baby, fr or chd, period specified by minister, in packages <=2.27 kg	0706101100	YES	NO	YES	YES	marine
		Baby, fr or chd, period specified by minister, in packages > 2.27 kg	0706101200					
		Baby, nes. fresh or chilled, in packages of a weight<=2.27 kg each	0706102010					
		Baby, nes, fresh or chilled, in bulk/packages of a weight >2.27 kg each	0706102020					
		exc baby, fr or chd, period specified by minister, in pack <=2.27 kg	0706103100					

	A	B	C	D	E	F	G	H
	Food	**Detail**	**HS CODE**	**Local Capability?**	**studied by Food Flow (HCA, 2005)?**	**studied by ONE (ROWPH 2005a)?**	**studied by RT (ROWPH 2005c)?**	**Overseas Transport Mode Assumption**
		exc baby, fr or chd, period specified by minister, in pack > 2.27 kg	0706103200					
		fresh or chilled, nes	0706104000					
10	16. Cheese	fresh and curd (including whey cheese)	040610	YES	YES (cheddar)	NO	NO	air
		grated or powdered	040620					
		processed, not grated or powdered	040630					
		blue-veined	040640					
		NES	040690					
11	17. Cherries, fresh	fresh	080920	YES	NO	YES	NO	air
	18. Cherries, prepared	prepared, whether or not sweetened	200860					marine
12	19. Chicken	domestic, whole, fresh or chilled	020710	YES	YES (breasts)	NO	NO	air
		fowls of 'gallus domesticus' - domestic, whole - fresh or chilled	020711					
		fowls of 'gallus domesticus' - domestic, whole - frozen	020712					
		cuts and edible offals of fowls of 'gallus domesticus' - domestic - fresh or chilled	020713					
		cuts and edible offals of fowls of 'gallus domesticus' - domestic - frozen	020714					
13	20. Corn (Sweet) - fresh	Sweet corn-on-the-cob, fr or chd, period specified by minister, in pack<=2.27 kg	0709903100	YES	NO	YES	YES	air
		Sweet corn-on-the-cob, fr or chd, period specified by minister, in pack >2.27 kg	0709903200					
		Sweet corn-on-the-cob, fresh or chilled, nes	0709904000					
	21. Corn (Sweet) - frozen	sweet corn, frozen	071040					marine
	22. Corn (Sweet) - preserved	preserved	200580					marine
14	23. Garlic - dehydrated (powders)	dried but not further prepared, nes	0712902000	YES	NO	NO	NO	marine
	24. Garlic - dried	Dehydrated veg, incl garlic but excl potato powder, n furth prepr, f mfg food prod	0712901010					marine
	25. Garlic - fresh	Garlic, fresh or chilled	070320					marine

	A	B	C	D	E	F	G	H
	Food	**Detail**	**HS CODE**	**Local Capability?**	**studied by Food Flow (HCA, 2005)?**	**studied by ONE (ROWPH 2005a)?**	**studied by RT (ROWPH 2005c)?**	**Overseas Transport Mode Assumption**
15	26. Lettuce	cabbage (head) lettuce, fresh or chilled	070511	YES	NO	YES	YES	air
		lettuce NES, fresh or chilled	070519					
16	27. Milk/Cream, concentrated or sweetened	not concentrated or sweetened, incl. cream	0401	YES	NO	NO	NO	marine
	28. Milk/Cream, fresh	concentrated or sweetened, incl cream	0402	YES	YES	NO	NO	air
17	29. Mushrooms, fresh	genus agaricus, fresh or chilled	070951	YES	NO	NO	NO	air
		all others, fresh or chilled	070959					
	30. Mushrooms, dried	genus agaricus, dried	071230					marine
		all others, dried	071239					
	31. Mushrooms, preserved	genus agaricus, preserved	200310					marine
		all others, preserved	200390					
18	32. Oats/Oatmeal	oats	100400	YES	YES (quick-cook)	YES	NO	marine
		groats and meal of oats	110312					
		oats - rolled or flaked grains	110412					
19	33. Onions	onions and shallots - fresh or chilled	070310	YES	NO	NO	NO	marine
20	34. Peanuts in shell	ground nuts (peanuts), in shell, not roasted or otherwise cooked	120210	YES	NO	YES	NO	marine
	35. Peanuts, shelled	ground nuts (peanuts), shelled, not roasted or otherwise cooked	120220					marine
	36. Peanuts, prepared	prepared	200811					marine
21	37. Pears, fresh	pears and quinces - fresh	080820	YES	NO	NO	YES	air
	38. Pears, preserved	Pears nes - prepared, whether or not sugared, sweetened or spirited	200840					marine
22	39. Peas, fresh	fresh or chilled	070810	YES	NO	YES	NO	air
	40. Peas, frozen	frozen	071021					marine
	41. Peas, canned	canned	200540					marine
	42. Peas, dried	dried	071310					marine
23	43. Peppers, bell, fresh	genus capsicum or pimenta - fresh or chilled	070960	YES	NO	YES	NO	air
24	44. Pork	carcasses and half-carcasses, fresh or chilled	020311	YES	YES	NO	NO	air
		cuts with bone in, fresh or chilled	020312					
		boneless cuts, fresh or chilled	020319					
		carcasses and half-carcasses, frozen	020321					

	A	B	C	D	E	F	G	H
	Food	**Detail**	**HS CODE**	**Local Capability?**	**studied by Food Flow (HCA, 2005)?**	**studied by ONE (ROWPH 2005a)?**	**studied by RT (ROWPH 2005c)?**	**Overseas Transport Mode Assumption**
		boneless cuts, frozen	020329					
		edible offal, fresh or chilled	020630					
	45. Pork (Ham)	hams and cuts, prepared or preserved	160241	YES	YES	NO	NO	air
		shoulders and cuts, bone in, cured	020111					
25	46. Potatoes, fresh	fresh or chilled, not seed	070190	YES	NO	YES	YES	marine
	47. Potatoes, frozen	frozen	071010					marine
26	48. Pumpkins/ Squash	fresh or chilled	0709909020	YES	NO	YES	YES	marine
27	49. Soda Biscuits	cntg >=25% wt of wheat, w/a	1905904210	YES	YES	NO	NO	marine
		cntg >=25% wt of wheat, in pack<=1.36 kg, o/a	1905904310					
		nes, cntg >=25% wt of wheat, in pack > 1.36 kg, o/a	1905904510					
		nes	1905904910					
28	50. Spinach, fresh	fresh or chilled	070970	YES	NO	NO	NO	air
	51. Spinach, frozen	frozen	071030					marine
29	52. Strawberries, fresh	fresh	081010	YES	YES (jam)	YES	YES	air
	53. Strawberries, frozen	frozen	081110					marine
	54. Strawberry Jam	in air-tight containers	2007991010					marine
		except in air-tight containers	2007991090					
30	55. Tomatoes, fresh	fresh or chilled	070200	YES	YES (fresh)	YES	YES	air
	56. Tomatoes, preserved	preserved	200210					marine
	57. Tomato sauces	sauces, incl. ketchup	210320					marine
31	58. Yogurt		040310	YES	YES	NO	NO	air