ELEMENTS OF SUSTAINABLE CANADIAN FOOD CONSUMPTION:

MEASURING SELF-SUFFICIENCY.

by

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Abstract

Elements of Sustainable Canadian Food Consumption:
Measuring Self-sufficiency.

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One aspect of sustainable agricultural development in industrialized nations is a move towards national self-sufficiency in food production. A self-sufficiency indicator (SSI) that complements the Organization for Economic Cooperation and Development's driving force-state-response framework on which Canada's agri-environmental indicators are based is proposed and demonstrated. A 2001 survey of Canadian household food consumption is analysed to estimate the areal measure of land required for its satisfaction exclusively by domestically produced primary agriculture. Canada is self-sufficient in field crops, which reflects its comparative advantage on the global market. The nation would require about five times the area currently under cultivation to be self-sufficient in fruit production. Vegetables consumed domestically account for just under half the area under cultivation.

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Dedication

For my mother, Joan Sule, and my sister, Joanne Christopher, for supporting me through this; to my partner Christine Rahim, for her encouragement and for living with me through it; but especially for my son, Alexandre Sule, for providing the reason for all I do.

Table of Contents

List of Tables

Table	Page

List of Figures

List of abbreviations

AAFC – Agriculture and agri-food Canada

AEI – Agri-environmental indicator[s]

CC – Carrying capacity

CTW – Cold trimmed weight

DCW – Dressed carcass weight

DOJC – Department of Justice Canada

DSR – Driving force-state-response

EF – Ecological footprint

FAO – Food and Agriculture Organization

FES - Food expenditure survey, specifically for the year 2001

LQI – Land quality indicators

MPC – Manitoba Pork Council

NASS - National Agricultural Statistics Service

NPP – Net primary productivity

OECD – Organization for Economic Cooperation and Development

SD – Sustainable development

SSI – Self-sufficiency indicator

USDA – United States Department of Agriculture

WCED – World Commission on Environment and Development

1.0 Introduction

Canadian people generally want to act in an environmentally responsible manner (Agriculture and Agri-Food Canada [AAFC], 2007) and more specifically have supported efforts, legislation and treaties to reduce the environmental costs of food production, both domestically and internationally (Lefebvre, 2005: 2). However, when there is no discernable impact on their local environment, people are less likely to modify their personal behaviour (Blake, 2001: 712). This has particular significance for the agricultural sector given its broad impact on the environment (Tilman, Cassman, Matson, Naylor & Polasky, 2002: 671) and the degree of urbanization in Canada (Statistics Canada [StatsCan], 2003a), in that consumers living away from farms cannot connect their eating habits with the environmental pressures posed by the production of their food. While anecdotal evidence exists that people are becoming aware their consumption choices affect the environmental sustainability of agriculture, for instance as suggested by the growing organic and local food movements (Junkins, Clark, MacGregor & McRae, 2005: 20), there is a lack of studies specifically connecting the two.

It is therefore proposed that a characterization of the sustainability of the agricultural-food (agri-food) system of Canada from the perspective of consumer demand be carried out in a way that is understandable and usable by producers, governments, institutions, non-governmental organizations, and consumers themselves. Establishing clear links between household food demand and the national food supply has already been proposed as a means of more firmly determining the sustainability of food consumption (Duchin, 2005: 103). However, simply disaggregating Canadian food consumption into the constituent crops required to supply it cannot be translated easily into environmental impacts, since not all food Canadians eat can be produced in the country.

The Canadian government, through AAFC, has set as a priority integrating sustainability concepts into agricultural practice and agri-food policy. While acknowledging rising global demand for food and arguing producers should continue trying to capture an ever-greater share, the government at the same time recognizes the uncertain long-term environmental impacts in doing so (Junkins et al., 2005: 19; Lefebvre, 2005: 2). Finding the conceptual area of Canadian land required to supply an amount equivalent to the domestic consumption of foodstuffs adds depth to assessments of sustainability because the ability of a society to continue is ultimately dependant on the self-sufficiency of the food supply, not only globally, but also nationally (Douglass, 1984: 6; Smit & Smithers, 1993: 510). Restated, self-sufficiency is a measure of food security, as has been recognized in the Canadian context for a considerable period of time (Cowell & Parkinson, 2003: 223; Pierce & Furuseth, 1986: 16).

Measuring the ratio of the area of land under cultivation to the area required to furnish domestic demand for each major category of food is therefore an indicator of agricultural sustainability and food security. Of course, this is not to suggest that the nation should ignore the economic benefits of global trade, any comparative advantage possessed, and plant physiologies in a sudden attempt to fulfill, for example, an ideological agenda. Sustainability strategies should not require shocking overhauls of society or force people to act against their self-interest (Robèrt, Daly, Hawken, & Holmberg, 1997: 80).

If sustainability essentially means not importing environmental goods and services in excess of our own supply or exporting wastes beyond the absorptive capacity of the domestic environment, as has been well-argued (Wackernagel & Rees, 1996: 54-55), yet the ability to fully comprehend the impact of our consumption decisions is hampered by a lack of information (Kissinger & Rees, 2009: 2314), a gauge of the environmental load posed by domestic agri-food demand could provide the conceptual bridge that influences producer and consumer behaviour. Although AAFC states "appropriate expectations" (Lefebvre, 2005: 3) of methods for tracking the environmental performance of the agricultural system include making scientific data accessible to the public and using the information to highlight the environmental impacts of the agri-food system to elicit behavioural change, their subsequent methodology focuses heavily on tracking environmental performance with respect to macroeconomic policy and strategy, and global trade (Lefebvre, 2005: 3-4; Junkins et al., 2005: 20). There does not appear to be a clear strategy for meeting the above-noted expectations.

The choice of data collected by AAFC to measure impacts to the ecosystems providing services for and receiving waste and bi-products from agriculture is intended to weigh environmental loading. Since Canadian agri-food producers and processers "are being urged to maintain acceptable levels of stewardship" (Lefebvre, 2005: 2), the real effect may be to highlight problems caused by certain production practices so that domestic farmers produce crops with lower impacts while those products associated with greater impacts are grown at a distance and imported. Interpretation of the data in this way thus causes a, albeit unintended, prescriptive effect. Further, the more Canada's agri-food system becomes integrated with the global system, the more complicated analyses of food sufficiency become (Smit & Smithers, 1993: 510). The introduction of counteracting data linking domestic demand and supply can provide justification for the economic internalization of some environmental impacts and avoid the justification for substitution. In addition, domestic consumption disaggregated into domestically-producible commodities offers a source of innovation in agronomic practices like intercropping and integrated pest management by illuminating choices from lists of candidate crops (e.g. Boivin, Grimard & Olivier, 2005: 86, table 12-2). Determining domestic food self-sufficiency in this way provides a direct connection between the social and environmental parameters of agricultural sustainability.

Relying on production and trade data to calculate residual domestic consumption quantities as is now the case (StatsCan, 2008a) masks the myriad sources that supply the globalized agri-food chain (Opara, 2003: 102) and thus also renders the overall environmental sustainability of Canadian food consumption blurred. Measuring the environmental impact of Canada's agricultural production assesses its contribution to the global total, but does not suggest the fraction posed by its citizen's demand. That Canada's contribution to the global food system is produced in ways that increasingly preserve the environment and conserve natural resources is laudable, but continuing integration with that increasingly complex system at the expense of self-sufficiency may leave Canadians vulnerable in hidden ways and thus negatively impact economic sustainability (AAFC, 1997: 7; Lefebvre, 2005: 2). Assessing the lifecycles of all the imported fresh and processed foods in the Canadian diet in order to assess the ecological cost is a daunting task (Graedel & Allenby, 2003: 183-196).

The rationale for augmenting supply-side assessments of the sustainability of agriculture with demand-side characterization can be explained in this way:

- From the beginning societies have sought, as a general rule, to continually increase food production (Altieri, Letourneau & Davis, 1984: 175); this has either been to support an increasing population or has spurred and supported subsequent population growth. This trend continues today.
- Nonetheless, as has been globally recognized for well over 25 years (Caldwell, 1984: 307), sustainability demands limits to growth in a finite world. This is even more critical to an industry heavily reliant on scarce finite resources like soil, petro-chemicals, mineral fertilizers, and fossil fuels.

- All humans have similar, basic energy and nutrition requirements of food (Food and Agriculture Organization [FAO], 2001) and the ostensible purpose of an agri-food system is to satisfy those needs.
- In a free-market economy a strong gauge of people's preference is consumer demand. However, under increasingly liberalized international trade, demand is influenced by the ever-larger choices available to the Canadian consumer. The often bewildering array of origins, even of the ingredients in an individual product, may defeat attempts to educate consumers about the environmental impact of their purchasing decisions.

There are thus two sides to the environmental impact of food: the sustainability of bulk production, which is relatable to large-scale assessment, intercession and guidance, and that of the consumer, whose capacity to relate to environmental effects may be nearer to arms-length and whose ability to react or create influence is therefore limited.

Of course modern agri-food systems have been extensively analyzed for their effects on the environment. In a review of the practices that have allowed agricultural production to double since about 1960, David Tilman (1999: 5995) noted that four grains, rice, corn, barley and wheat, annuals once considered comparatively rare, now occupy almost 40% of agricultural land and have "become the dominant plants on earth." He determined this came with an rise in nitrogen application by a factor of almost 7 and in phosphorus fertilization by almost 3.5 times (Tilman, 1999: 5996) that has polluted terrestrial and aquatic systems and contaminated groundwater (Tilman et al., 2002: 672). Pesticide use associated with intensive agriculture bioaccumulates and persists in the abiotic environment, while at the same time selecting for resistance amongst the pests they are designed to kill. Microbial resistance to the antibiotics used routinely in modern animal husbandry poses a risk to humans then exposed to less-treatable strains of diseases (Tilman et al., 2002: 672). Natural land converted to agricultural use shows reduced biodiversity, although agroecosystems may still be more diverse than urban ecosystems (McRae, Smith & Gregorich, 2000: 15).

In Canada, efforts to include such environmental impacts into the agriculture industry's monitoring framework began in 1993 and mimicked the driving force-state-response (DSR) model developed by the Organization for Economic Cooperation and Development (OECD) that was adopted for international work linking food production to the environment (FAO, 1997; McRae et al., 2000). Once AAFC was directed to incorporate sustainable development principles and practices into its own management system and the way it oversees the wider industry, it generated guidance documents to provide a strategy to integrate environmental issues with economic and social interests, and suggested criteria under which environmental impacts might be assessed (AAFC, 1997: 1, 13). After criteria are established, related data are collected representing trends in environmental performance that respond to changes in policy, support and guidance, or behaviour; because of this responsiveness, these data are called indicators. McRae and colleagues oversaw the initial agro-ecosystem indicator (AEI) development and a first series of results (2000). Subsequent work expands and further operationalizes the AEI, then reports results that supplant those of the first effort (Lefebvre, Eilers, & Chunn, 2005; Lefebvre, 2005: 6).

The groundbreaking Canadian work takes the perspective of farmers and agri-food producers (McRae et al., 2000: vii) and the "policy challenge," as they see it, is to set environmental, social and economic benefits at an "optimal and sustainable" level (McRae, et al., 2000: 1). The term "optimal" is given no immediate context by McRae and co-workers, but it suggests an attempt to assuage producers who fear their economic rights will not be respected through the imposition of environmental monitoring and controls. To that end, there is recognition later that farmers are not directly compensated for conserving environmental benefits or taking steps to manage risks (Lefebvre, 2005: 20). Also, economic and environmental optimization occurs, for example, when fertilizer or pesticide is applied such that the greatest yield is realized with the least unintended effects (i.e. nutrient run-off or pesticide overspray) (Koroluk, Piau, Grimard, Bourque & Korol, 2005: 56, 58). The second AAFC report explicitly models its definition of sustainable development after the growth-oriented one of the UN's Brundtland Commission, and states the sustainability of agriculture is a "key aspect" of any such development (Lefebvre, 2005: 2; WCED, 1987: 8).

This salutatory section will be followed immediately with a discussion of human carrying capacity and its relationship to land area, thereafter by an overview of agricultural development that illustrates the historical supply-side focus, the global distribution of land resources and advances in yield growth. More depth will be added to the discussion of the agri-environmental indicators before concluding with an introduction to the study methodology and an outline of the remaining work.

1.1 Human carrying capacity

Carrying capacity can be defined basically as the largest animal populations that can be supported by the resources of a given area without ruinous deterioration of the environment (Chambers, Simmons & Wackernagel, 2000: 46). When applied to modern humans, carrying capacity can be interpreted as a demand on the land base and has been expressed in a variety of ways.

One simple yet useful method for determining carrying capacity is per capita arable land available for grain production, since most of the world derives nutrition largely from that source (Kendall and Pimentel, 1994: 199) and this is unlikely to change in the "foreseeable future" (Cassman, 1999: 5952). Such an approach can be expanded to include a qualitative assessment of available land, for example, as determined in the Canada Lands Inventory (CLI) classification system (AAFC, 2008a) or to illustrate the unsustainability of discrete populations, for example, dense urban centres that require far more food than the adjacent farmlands can provide (Wackernagel & Rees, 1996: 86-88). Another way to broaden this approach to is to include a greater variety of foodstuffs. Such a broad scheme fits into one of six categories of methods Cohen identified as being suitable to calculate human carrying capacity (1995a: 343). Ultimately, a direct characterization of the relationship between crop area and people describes human carrying capacity in one of the most tangible ways since people must eat to survive.

In the Canada the amount of dependable agricultural land, namely CLI classes 1, 2 and 3 lands has been in decline for some time, mostly as a result of urbanization (Hofmann, Filoso & Schofield, 2005: 10). These classes denote a range of limitations from none for the well-drained, deep soils of class 1, to some restrictions on crop choices and conservation practices for class 2, to the "moderately severe" restrictions that may tightly limit the choice of crops grown, "the timing and ease" of sowing, tillage, and harvesting, and conservation practices (AAFC, 2008a: ¶15-¶17). Figure 1.1 shows the relationship between the supply of and demand for agricultural land in Canada for a 50-year period ending in 2001.

Hofmann and colleagues noted that the excess cultivated land shown in figure 1.1 is being derived from marginal lands that suffer from *inter alia* erosion, slope problems and soil fertility deficiencies; in other words, limitations that are more than moderately severe (AAFC, 2008a: ¶18-¶21). This is, by their definition, unsustainable (Hofmann et al., 2005: 9). To be clear, although Canada

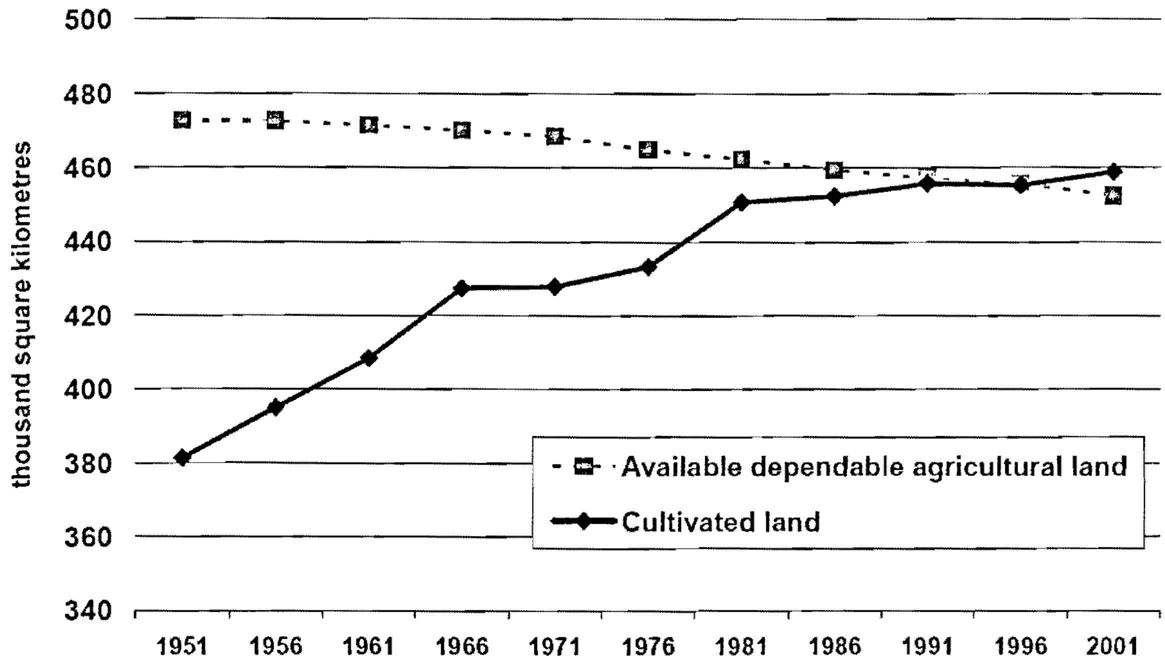

Figure 1.1: Supply of dependable agricultural land and demand for cultivated land in Canada. (Reproduced from: Hoffmann et al., 2005: 10, figure 5).

covers nearly 1 billion hectares of land and inland water (Niu & Proux, 2005: 24), the share of dependable farmland is as little as 5% and of prime class 1 land a tenth of that. Further, since over half of class 1 land is in Ontario alone, that class may be at higher risk of loss considering Ontario is experiencing most of Canada's urban population growth (Government of Ontario, 2007: ¶7, ¶21; Hofmann et al., 2005: 5, table 1). Since in part climate and soil factors guide farmers' decisions as to what to plant, the loss of scarce land, soil types or nearby supporting natural ecosystems could translate into lost capacity to produce certain crops (Rostad & Padbury, 2005: 98). Therefore, ensuring the continuation of elements within the greater system ensures the maintenance of overall carrying capacity and contributes to global sustainability.

History is replete with examples of societies who tested the limits of their agri-environmental systems or were forced to rely on agricultural systems away from their populace. The record of possible outcomes upon reaching those situations is as interesting as it is varied and makes up the next section.

1.2 Dedication to surplus: the origin and development of agriculture.

Throughout the history of human agriculture there is evidence that maximizing production while optimizing labour has been the ultimate goal, regardless of the farmers' own needs for the products. An interaction of indeterminate origin[1] (Cohen, 1995b, 37) began even before humans first tended plots: some kind of semi-permanent agriculture caused population increases, which spurred agricultural need, leading to expansion and surplus, causing further population increases, spurring further need, expansion, surplus and so on. Eventually, trading and feeding imperialist armies added to and occasionally eclipsed domestic populations as the chief users of the surplus, but even colonialism (mainly, but not only, by European nations) can ultimately be ascribed to the need for more food. In modern times, seemingly altruistic notions of finally ending world hunger led to stunning leaps in productive capacity that coincided with still more dramatic leaps in population.

Humans were likely already living in settlements year-round, or nearly so, when the practice of cultivating important plants, rather than gathering them,

[1] In other words, a "(w)hich came first, chicken or egg?" situation (Cohen, 1995b: 36).

caught on some 10000 years ago (Smith, 1995: 51, 210). These early settlers already had extensive knowledge of the lifecycles of these plants and had developed successful methods and tools for collecting and processing the seeds (Smith, 1991: 14; Smith, 1995: 210), but had yet to face the population density pressures that made the effort of permanent agriculture worthwhile (Smith, 1991: 14). Although growth in human numbers most commonly caused density pressures, environmental perturbations had similar effects. In the Americas, for instance, the Altithermal period immediately following the last ice age was marked by a warming, drying climate that caused vegetation to vanish from historical areas along with the animals, including the Megafauna, that it fed. Thus a declining food supply for a constant population has a similar effect to that of a population growth rate that exceeds yield growth. The beginnings of agriculture in the New World can be traced to this time (Smith, 1991: 14-15).

With the inception of settlement agriculture, humans began having some success at achieving constant food production. Early agricultural settlements were some 2 to 6 times larger than their non-agricultural contemporaries and agricultural economies were more affluent, for example, as evidenced by the larger houses. Proximate endogenously produced food also afforded early settlers the time to create an infrastructure that included food storage facilities and flood protection installations (Smith, 1995: 81).

It seems then that at least some early agrarian societies produced more food than was required by the extant population. Within ancient agricultural catchments[2] "the human drive to secure the greatest possible amount of food for the least possible labor [sic]" that contributed to the very domestication of plants (Helbaek, 1959: 365-366) likely also meant an early tendency for surpluses. Under these conditions population levels rose to meet and exceed food production, straining the sustainability of the system. To relate an example, the so-called Cradle of Civilization, in modern-day Iraq, rose from these first agricultural settlements (Braidwood, 1954: 41). The recounting of the end of these "Old Testament societies" traditionally blamed outside invasion, but newer evidence suggests a general collapse in soil tilth and the inability of the agricultural system to support the dependant population (Douglass, 1984: 3).

In other cases production was increased to meet the needs of growing populations. In the first settlements around the Mediterranean Sea, people were clustered in river deltas. When people could no longer be fed from the deltaic farms, innovations beget terracing and other improvements, which increased yield to meet the growing demand (Semple, 1928: 62). As the Egyptian civilization gave way to the Roman Empire and more and more land was cleared of forests to make room for farmland, soil erosion compounded the problem of declining soil fertility, finally turning the North African granaries of the Roman Empire into desert and marginal land (Douglass, 1984: 3).

Other places in the world had similar experiences. In ancient Sri Lanka, farmers invented a reservoir-based irrigation system that, combined with the

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[2] Notwithstanding obvious natural boundaries, some early nations were defined by the areas of their agricultural production, for example, Egypt in the 5^{th} century BCE (Semple, 1928: 66).

vegetarian philosophy that accompanied Buddhism to the island in the 4th century BCE, gave regular surpluses that allowed for a growing kingdom. The link between this system and its dependant population was so obvious that invaders from India attacked the water tanks in order to quell the people (Senanayake, 1984: 227). Indeed, Sri Lanka is possibly only now returning to population levels first experienced almost a thousand years ago (Senanayake, 1984: 227; United Nations Population Division, 2009). In pre-Columbian America too, Mayan centres succumbed to population pressures that badly eroded soils could no longer bear (Douglass, 1984: 3).

As mentioned, evidence exists that climatic shifts, namely periods of drought, perhaps accompanied by abnormally warm or cool temperatures and lasting from a few decades to several centuries, contributed to the collapse of various societies by reducing agricultural production and the availability of game and wild plants. Thus some societies grew to what were sustainable population and agricultural production levels under the given environmental conditions. When those conditions changed rapidly and radically the peoples' technical prowess was overwhelmed and the societies collapsed or were drastically reduced (Weiss & Bradley, 2001: 610).

Contemporaneously with one such "forced regional abandonment" by the Anasazi peoples of their North American home in the 13th century CE as a result of an extended climate perturbation (Weiss & Bradley, 2001: 610), Old World peoples were beginning to understand the geographical extent of the Earth

(Osterhammel, 2005: 71). From about the 11th to the mid-13th centuries, European populations rebounded at "unprecedented rates" (Smith, 1991: 47) from losses suffered under the Roman Empire and the Dark Ages that followed (Smith, 1991: 38-42), while agricultural production "expanded greatly" as more lands were cleared for cultivation (Smith, 1991: 47). The dawn of European colonialism marked the beginning of massive imports of agricultural products that augmented the limits of local production (Pfeiffer, 2006: 6). In other words, people began to import carrying capacity, on which they became dependant for survival, rather than simply trading to add value to products through variety or rarity.

In the 15th and 16th century, the voyages of European sailors were primarily exploratory ones also concerned with finding and obtaining spices. Many farm animals were slaughtered across Europe every fall owing to a consistent shortage of winter feed and the meat had to be preserved with salt and spices, the latter of which only grew in tropical countries (Parry, 1966: 32). Thus the initial journeys were dedicated to discovering and securing the origins of the important spices and mapping the most expeditious route by which to transport them home. Whenever the Europeans encountered other peoples, they found societies based on agriculture (Osterhammel, 2005: 73-74). In some instances, they found populous, long-standing centres of agricultural trade featuring products from distant lands; in others, they found relatively uninhabited lands. In both cases, when conquest was possible and desirable, the colonizers forcibly seized the land and committed it to commercialized agriculture (Caldwell, 1984: 303; Osterhammel, 2005: 74).

European overseas colonization was a relatively slow process, beginning with the American colonies in the early 17th century[3], then Australia in the 18th and New Zealand in the 19th centuries (Federico, 2005: 32). Throughout this time agriculture was economically paramount with respect to its contribution to national income, employment creation and generation of personal wealth (Cain & Hopkins, 2002: 66). The willingness of citizens to immigrate to these new lands and settle was driven by population pressures in their homelands. The migrations and the pace of land clearing for farms quickened over time, not only from Europe overseas, but also as a kind of regional colonization within Russia, Eastern Europe, South America and China, as internal populations reached critical levels and were forced to find new farmland (Federico, 2005: 32).

As an example of how the rate of agricultural extensification quickened, the US began recording land area in farms in 1850 and up to that time 118 million hectares had been put under the plough. By the time the frontier was closed as the turn of the 19th century approached, some 250 million hectares were being farmed (Federico, 2005: 32). Worldwide today there are well over 1.5 billion hectares committed to crops and cultivated trees (excluding those used for fuel, fibre and wood) and almost 3.5 billion hectares used as permanent pasture lands from the available 13 billion hectares. The remaining 50-60% of

[3] The pace of North American migration did quicken however and Thomas Malthus (1766-1834) believed the immigration he was observing was the exponential growth that formed one of the pillars of his population theory (Seidl & Tisdell, 1999: 397).

the Earth is unusable for agriculture short of a stunning technological breakthrough or is forested (Federico, 2005: 5). That the limit of Canada's agricultural system with respect to land area has been reached was introduced on page 7; it has stabilized at about 67 million hectares for some time (Eilers & Hoffman, 2005: 43). That the limit has been reached should not be a shock, since increasing output has long been one of the "primary objective[s] of Canadian agricultural policy" (Junkins et al., 2005: 20).

Thus it can be seen that outgrowing lands, soil fertility problems, rising demands of growing populations, and effects of changing climate that can be observed in the world today have all been faced by farmers since the first seeds were sown. In sum, section 1.2 has shown that while the chief goal of agriculture has, or course, always been to provide adequate food, the means to that end has seemingly always involved wringing the maximum production from farms regardless of local or instant needs and frequently to the permanent detriment of the land. Even peoples who live within their carrying capacity can exceed their food supply when yields are affected by a changing environment. For most of the period since the Neolithic revolution the only way to increase production was to expand the cultivated area, either through conquering or clearing new land, but with all the available land now under cultivation at least the latter avenue is closed.

Expanding the area under cultivation is not the only way to increase production. There have been enormous gains made in yields from the mid-1960s into the present millennium through the introduction of modern, hybridized varieties (MV) of rice, wheat and corn. Relying heavily on fertilizer inputs, chemical pest control, irrigation and mechanization, these advances are collectively known as the green revolution. Growers also favoured hybrids that can be planted densely to take advantage of greater nitrogen fertilization (Duvick & Cassman, 1999: 1624). Notably though, without nitrogen fertilization MV yields are only moderately above those of the un-hybridized varieties (Khush, 1999: 646, 647-648). Yield growth has slowed over time (Khush, 1999: 650) and improved varieties of root and protein crops, mostly beans, have been slow to develop (Evenson & Gollin, 2003: 760).

Since Canada is a net food exporter (Niu & Proux, 2005: 24), it is not the ability of the nation to feed itself through trade that is at issue here, but rather its self-sufficiency in the range of products that constitute diet as reflected in consumer demand. Scholars have noted that global per capita caloric intake has been sufficient for some time[4], mostly due to the ample supply of grain. It is nutritional balance that now concerns researchers, something hybrid cereals and the accompanying "production paradigm" cannot address (Welch & Graham, 1999: 2). On the one hand, there is the "hidden hunger" of micronutrient (vitamin and mineral) deficiencies plaguing developing nations, while on the other there is the over-consumption of energy-rich and fatty foods causing an obesity "epidemic" in the developed world (Iyengar & Nair, 2000: 332-333).

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[4] Which is not to say that everyone is amply fed; wars and inequitable distribution, to give two examples, stand in the way of complete hunger prevention (Welch & Graham, 1999: 02).

Since Canadians, like all people, require a complete balance of foods for healthful sustenance (FAO, 2001) importing nutrition, as calories, is importing carrying capacity. Reducing imported agricultural carrying capacity means indentifying the gaps in the ability to supply domestic demand.

1.3 Connecting Canadians to their land

The AEI match "scientific knowledge and understanding with available information on resources and agricultural practice" (Eilers & Lefebvre, 2005a: 8) and their development was set using the following approaches:

- Policy relevance ensures the environmental impacts of concern to "governments and other stakeholders" are the focus.
- Science-based and able to withstand the rigours of empirical analysis, though the latter may require several iterations.
- Communicable to both stakeholders and the lay public.
- Sensitive to trends across the whole system over time.
- Economically practicable and reliant, where possible, on existing data.

The DSR-variant framework on which Canada's AEI is based has been explained by AAFC in this manner:

> - Pressure: environmental stresses that may influence aspects of agricultural production such as the selection of crops and management practices used for production.

- Outcome: ultimate impact of agricultural production on the health of the environment (soil, air, water, biodiversity).
- Response: use by producers of key management options which [sic] influence the impact of agriculture on the environment.

(Eilers & Lefebvre, 2005a: 8; original emphasis removed).

The report further recognizes that "key gaps" exist in understanding the environmental impact of the agri-food industry. Future efforts will be addressed on the supply side through integrating economic and environmental indicators to provide a broader understanding of the effects of changing agricultural policy. There will also be an attempt to capture the economic value of the positive and negative externalities of agriculture in an effort to balance environment and economy (Lefebvre, 2005: 4). The following table 1.1 shows the five categories under which Canada's agri-environmental indicators (AEI) have been developed, the AEI, and if they are operational.

The government's stated policy objective of advancing farm income stability is supported by the AEI, especially the ones in operation now, since they are the most reflective of immediate risks to yield (Junkins et al., 2005: 20). Seemingly, the indicators that would be of more consumer or social interest but that might tend to act against the economic interests of the agri-food sector are those still under development. Take for example the water quality indicator for

Table 1.1: Indicator groups, AEI and AEI in use by AAFC.

INDICATOR GROUP	INDICATOR		OPERATIONAL (Y/N)
Environmental farm management	Soil cover		Y
	Nitrogen use efficiency		Y
	Energy use efficiency (energy output/energy input)		Y
	Water use efficiency: irrigation		N
	Integrated pest management		N
Soil quality	Soil erosion	Water erosion	Y
		Wind erosion	Y
		Tillage erosion	Y
	Soil organic carbon		Y
	Soil salinity		Y
	Trace elements		N
Water quality	Nitrogen		Y
	Phosphorus		Y
	Pesticides		N
	Pathogens		N
Air quality	Greenhouse gases		Y
	Ammonia		N
	Particulate matter		N
Biodiversity	Wildlife habitat on farmland		Y
	Wildlife damage to crops and livestock		N
	Invasive alien species		N
	Soil biodiversity		N

Source: (Lefebvre, Eilers, & Chunn, 2005)

pathogens that recognizes manure storage and application poses a direct risk to the health of the surrounding population from runoff to surface waters or groundwater infiltration. Prospective responses to adverse levels of risk include increasing manure storage capacities and ensuring optimum timing for its application (Topp, van Bochove, Thériault, Dechmi & Lapin, 2005: 138, 139). Responding this way fails to recognize that intensive livestock operations frequently generate manure in excess of the capacity of the nearby land base to receive it (Carpenter et al., 1998: 8).

1.4 Self-sufficiency is sustainable

Utilizing the pressure-outcome-response framework to structure agricultural environmental monitoring, Canada is developing indicators to connect environmental states to agri-food system responses. This will not necessarily lead to sustainable agricultural development, which requires the continuation of each of the environmental, social and economic components of the system. Since the social component of the system comprises the nation's citizens and their continuation requires an adequate food supply, sustainable agricultural development requires the self-sufficiency of the nation's food supply.

It is hypothesized that a self-sufficiency indicator (SSI) connecting the ability of a nation to supply food with the demand for it posed by its citizens adds to assessments of sustainability of the national agri-food system. The goal of this work is to express the ratio between existing areas of primary food production (i.e. crops) and that conceptually required to supply Canadian household consumption and show how this information can influence potential agri-food system responses and wider agricultural policy considerations. It is asserted that such an indicator can incorporate additional aspects of sustainability into the Canadian agri-food system without necessarily impairing its interconnections with globalized trade or otherwise interfering with stated Canadian agricultural policy objectives.

Chapter 2 contains a review of literature establishing the nature of sustainable agriculture and agricultural development. It also presents views on agri-indicators and their use in characterizing sustainability. Land-area indicators and indicators and indices of carrying capacity are also reviewed. Chapter 3 introduces the Canadian household consumption dataset for 2001 and provides the method for relating consumer quantities first to mass units of constituent plant and animal products, then to equivalent domestically-producible foodstuffs, and finally to land areas. Chapter 4 presents results from the analysis, discusses how Canada's current efforts to monitor agri-environmental sustainability could be augmented by consumer characterization, and offers insight into and choices for the future path of sustainable agricultural development. Finally, chapter 5 delivers some conclusions.

2.0 Literature Review

Discussions of sustainable systems require fixed definitions, specific contexts, and defined spatial scales for any element of the system under consideration. Sustainable agricultural development approaches consider the integration of environmental, social and economical elements so that a cultural ecosystem from which food and fibre resources are extracted may continue to function. Indicators provide information about the functioning of agroecosystems; particularly useful are indicators from which inferences about difficult-to-measure properties of the system can be made. Frameworks combine multiple indicators to provide a more complete picture of the health of a system. Many frameworks use indicators of, or are based on, land area demand, but most use production data to demonstrate the impacts of supplying the global markets. Land area demand and human carrying capacity are interrelated and can become more so as yield growth rates stabilize.

2.1 Sustainable agriculture defined

It is typical in the literature to begin discussions of sustainable development (SD) by breaking down terms and defining the concepts from within. For example, the term sustainable (or sustainability) has been defined in countless ways. Since fundamentally sustainability "always concerns temporality and [...] longevity" (Costanza & Patten, 1995: 194), a lexical definition, to continue through time, is invoked with regularity, at least introductorily (Brown, Hanson, Liverman & Merideth jr., 1987: 713; Costanza & Patten, 1995: 195;

Dixon & Fallon, 1989: 74; Douglass, 1984: 3; Hansen, 1996: 117). Since nothing can last forever, Costanza and Patten suggest a limiting temporal criterion in which the length of time a component within a "nested hierarchy of systems" must endure to be considered sustainable is equal to or greater than the expected lifespan of the component under normal behavioural conditions (1995: 195). For example, a single farm field under a typical three-crop rotation requires a fallow period to regenerate soil fertility and may continue indefinitely under such management. However, if farmer omits the fallow period for this particular field, its fertility may decline over time, although *ceteris paribus* the whole farm may remain continually productive. Conway sees agricultural systems as such a hierarchical order of systems or as levels of ecological organization ascending from a single field to the watershed or regional scale, each one "nested" within the next (1985: 34). In fact, it has been suggested the hierarchy could include the entire Earth as an agroecosystem (Walter-Toews, 1996: 687). The literal view is a polar one, something is sustainable or it is not. Shearman worries literal usages lead to "self-referential" definitions arising from empirical examples that may be difficult to apply elsewhere (1990: 2).

Others have found sustainability too hard to define at all, calling it instead an idealized goal because it cannot be directly measured. However, once the ideal is stated, progress toward or away from, or comparison with it can be made and an indication as to the "level and duration" of the sustainability of the system can be defined (Zinck et al., 2004: 89). Viewing sustainability in this way, as a continuum between the polar extremes, is probably more realistic. In developing the ecological footprint methodology, Wackernagel and Rees, too, shied away from a clearly stated meaning, instead saying that reducing the difference between what the global ecosystem can provide and absorb and what humans demand of it in these regards moves us towards "[d]eveloping sustainability" (1996: 159-160). Although they set no explicit upper limits to the world's ecological capacity, a fact for which they have been criticized (van den Bergh & Verbruggen, 1999: 64), their assertion that a holistic response is necessary to reduce human impact on the environment is a sound one. In any case, what is definably and measurably sustainable at one scale may not be at another (Brown et al., 1987: 717), so perhaps "sustainable" is best defined simply as "the common-sense notion that we don't want to move ahead one step only to slip back two" (Dixon & Fallon, 1989: 73).

More expansive definitions for agricultural sustainability have been articulated. Conway says formerly natural ecosystems are converted into "hybrid" agroecosystems, which are co-opted to produce food and fibre for human use (1985: 34). Agroecosystem sustainability depends on ecological concepts of resilience and resistance; the former describes the ability of the system to withstand stresses and perturbations without too great a variation in yield, while the latter refers to the time it takes the system to return to its normal state (Power, 1999: 185-186). Stresses can be small and periodic, but are usually continuous, while perturbations are discrete, unusual occurrences of significant magnitude (Conway, 1985: 35). Tilman also takes an ecological viewpoint, noting additionally that richer species composition and higher species diversity work towards the continuation of any ecosystem (1999: 5999). Sustainable rice production in Japän can involve a "mutually adaptive" set of integrated cultivation practices, a "management syndrome," that are less effective in maintaining yield in smaller or different groups (Andow & Hidaka, 1989: 448). At their interface, agriculture has always tested the resilience of nature (Altieri et al., 1984: 175).

For Brown and co-workers, sustainable agriculture is qualitatively conservative of resources like soil and water, respectful of biodiversity, and socio-economically productive (1987: 714). Zinck and colleagues hold that agricultural sustainability is a concept that "implies" continuous preservation of natural ecosystems, maintaining production while minimizing inputs, and ensuring income equity for producers, their families and communities, while providing "basic food needs" (for whom is not specified) (2004: 89). Here again Shearman has concerns: if a system is cast as sustainable, what aspersions will this cast on other existing or "conventional" systems? Using "sustainable" as a modifier to an activity implies the other ways of doing things can lead in socially undesirable directions (1990: 2).

There are three perspectives that have dominated investigations into sustainability for at least 20 years, since the concept was in its nascence (Shearman, 1990: 1). The economic point of view is usually predicated on continued economic growth and often struggles to value non-market goods and services, such as those provided by ecosystems. The social viewpoint considers the maintenance of individual well-being, from the basic provision of shelter, food and water to attaining more advanced social rights like "security, freedom, education, employment, and recreation." The social perspective is invoked by those seeking equitable resource allocations or to define the maximum supportable number of people for a given resource pool. Finally, an ecological or environmental assessment takes into account the continuation of ecosystems, including the abiotic components and all aspects of biodiversity. Notably, there is a connection between short-term variability in the biological aspects of diversity, as opposed to the abiotic elements, and longer ecosystem sustainability. It has been observed that pest management that improves the resilience of a cultural ecosystem has possibly decreased its long-term resistance (Brown et al., 1987:716). These three viewpoints, or variations of them, are often combined when creating holistic approaches sustainable development.

2.2 Approaches to sustainability

A sustainability concept forms the basis for an "integrating framework" for theoretical and empirical investigations (Smit & Brklacich, 1989: 411). Once the goals are defined, approaches to assessing the current level of sustainability can be taken and actions setting a trajectory towards meeting the goals can be implemented. Examples of frameworks are provided later after a review of approaches to sustainability.

In his seminal work, Douglass (1984: 4-6) integrates traditional views and methods of agriculture with new analyses and alternative methods in an effort to give meaning to agricultural sustainability from the disparate voices arguing narrower definitions. He describes three approaches to agriculture that arise in light of growing evidence that agricultural systems are overtaxing the environment, are possibly incapable of meeting future global demand for food and are growing less connected to the farmers, their families and their communities.

The first set of approaches considers agri-food systems sustainable if they are self-sufficient. This viewpoint can support the industrialization of agriculture as the means to feed an ever-growing population in the developing world or to provide meat and other energy-rich foods for the economically more advanced nations (Douglass, 1984: 6). Ensuring food sufficiency for a defined time period requires matching estimates of demand under dynamic socio-economic conditions with estimates of supply under variable climatic conditions for each major food group. These are mostly economical estimations and tend to view any limits not as physical, but as opportunity cost transactions in which resource substitutions are always an option. This overlooks the fact that the fundamental resource of agriculture, the land, is fixed in amount and productively finite if mistreated, and is thus non-substitutable (Douglass, 1984: 7-10).

Douglass' next group of approaches is ecological and sets sustainability as the upper level at which the earth can continually provide the resources that support food production and absorb the wastes that it generates. For agricultural systems that depend at least to some degree on natural and renewable sources of power, pest control and fertilization, farmers who engage in unsustainable practices risk declines in land fertility (Douglass, 1984: 11). The use of non-renewable resources, chiefly fossil fuels and petrochemicals, temporarily boosts the productivity of the land while they are available. This may degrade the stock of renewable resources, either by polluting or structurally altering natural ecosystems irrevocably, or by supporting human population growth that, in turn, causes additional strain on space and resources (Douglass, 1984: 12-13). That environmental degradation may be masked by increasing inputs to the agri-food system or energy to mitigation efforts supports the idea that system sustainability is more prediction in a current context and verifiable only in retrospect (Costanza & Patten, 1995: 194). Conway observes this too, saying a measured decline in productivity may or may not indicate unsustainability, but in any case, the system can collapse fast and unpredictably (1985: 34).

The final group Douglass recognizes are those who raise social concerns of sustainability, expressing them as community values that encompass the entire agroecosystem, including human members. The resulting paradigm is usually called alternative agriculture because it rejects a competitive model of large-scale industrialized agriculture in favour of a cooperative, locally-focused one. This mutually-supportive model of farming extends to the protection of nature, includes social justice and intergenerational equity, and encourages a decentralized power structure that leaves decision-making in the hands of the community, rather than the boardroom (Douglass, 1984: 17-19).

Like Douglass (1984), Dixon and Fallon (1989) also find sustainability concepts can be placed in three groups: the physical accounting of a single resource, the description of physical and environmental interactions among groups of resources and ecosystems, and the accounting of broader social-environmental-economic interactions (73-74).

Over a century ago, biologists working in forestry and fishery recognized that over-harvesting one season reduces the yield in subsequent years and conceptualized maximum sustainable yield (harvest) as the amount of growth or reproduction in excess of replacement growth or stock (Brown et al., 1987: 714). This work was limited to the analysis of a single biophysical resource in isolation from socio-economic development, with a view to preserving the *status quo* (Dixon & Fallon, 1989: 74). Later, foresters altered their approach, but not the underlying principle of sustained yield, so that the forest would be harvested in a way that guided its development to even-aged stands (Brklacich, Bryant & Smit, 1991: 3).

Considering a resource in isolation can mask system unsustainability (Smith & McDonald, 1998: 21), giving rise to methods for describing interactions amongst resource exploitation systems (industries) or how such resource exploitation impacts ecosystems. Accounting for interactions in this way has been useful for achieving constant production in agroecosystems. The example given is rubber plantations that replaced the native ecosystems in Malaysia in the early 20th century; it is noted in this case that both ecosystems are sustainable, just not when simultaneously co-located (Dixon & Fallon, 1989: 75). Like Douglass (1984: 8), Dixon and Fallon (1989: 76) identify in these "trade-offs" opportunity costs, but as the physical usefulness of productive assets against the utility of the original ecosystem, instead of in purely economic terms. The latter authors still appreciate that some valuation system needs to be applied and stress the influence resource managers have through policy- and decision-making. This suggests that ecosystems have more than economic value, which will not necessarily be recognized in a market milieu, but that could be normatively assigned worth on the basis of an intuitive intrinsic value found in nature (Shearman, 1990: 5).

The last group of concepts Dixon and Fallon (1989: 76) recognize are those that describe comprehensively the environmental, social and economic interactions and impacts of resource exploitation activities. When these elements are considered together, they constitute a measure of sustainable development where the goal is not simply the physical maintenance of a resource or continuation of a production system, but the advancement of the individual and collective welfare of society. Most definitions of sustainable development include environmental, social and economical concerns (Costanza & Patten, 1995: 194). While not defined explicitly by Dixon and Fallon (1989), others have called development "directed social change" intended to harness the beneficial aspects of a socio-economic system and guide them to a cooperative equilibrium (Niu, Lu & Khan, 1993: 180). In this way, development can be conceived as the qualitative advancement of the system, as opposed to its quantitative growth (Daly, 1987: 323).

The World Commission on Environment and Development's (WCED) springboard definition from which many later approaches to sustainable development are launched is often quoted incompletely and simply that fulfilling the needs of the present generation should not obstruct future ones from fulfilling their own. Tellingly, it continues:

> The concept of sustainable development does imply limits – not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities. But technology and social organization can be both managed and improved to make way for a new era of economic growth (WCED, 1987: 8).

Truncation has arguably been necessary to make SD concepts inclusive and applicable to different sectors and interests. Indeed, Caldwell recalls that conflicting priorities between the developed and developing worlds for environmental and economic foci, respectively, nearly derailed the first attempts to define ecologically sustainable development some 40 years ago (1984: 299). That limitless economic growth is desirable is highly debatable; economists who assume growth is both desirable and inevitable tend to ignore sustainability altogether (Brown et al., 1989: 716). This concept is in fact sustainable growth, which is an oxymoron (Daly, 1990: 2). The Commission finishes the paragraph appropriately to their mandate, stating the opinion that global poverty can be mostly overcome, proffering a normative statement condemning any poverty, and noting extreme negative economic conditions encourage susceptibility to "ecological and other catastrophes" (WCED, 1987: 8).

An academic approach to sustainable agricultural development suggests as a goal: a system capable of fulfilling human needs for food, fibre, and related products, both now and in the future; one that conserves resources, is economically viable, protects the environment and, to the greatest extent possible, relies on renewable rather than non-renewable resources to ensure long-term societal survival (Bavec, Mlakar, Rozman, Pažek & Bavec, 2009: 90; Rao & Rogers, 2006: 441; Reganold, Papendick & Parr, 1990: 112; Smith & McDonald, 1998: 15). The definition proposed by Agriculture and Agri-food Canada is similar but decidedly nuanced. To develop sustainably, an agri-food system need only protect those resources on which it depends, although in a manner that is "compatible with surrounding natural systems and processes" (Lefebvre, 2005: 2). While contributions to wider socio-economic conditions are mentioned, of course including the supply of safe and healthful food, protection of the socio-economic status of agri-food businesses, labourers and their families is clearly specified (Lefebvre, 2005: 2).

2.3 Sustainability frameworks

Sustainability frameworks are contextual guides that govern the choice of indicators and influence how the information is viewed and reported (Tomalty et al., 2007: 9). Robèrt and co-workers (1997: 80-81) outline a sustainable development framework based on a theoretical model governed by prerequisites that include:

i.) a rational view of the world,

ii.) a definition of sustainability supported by science,

iii.) a recognition that individuals should not be forced to act against their self-interest,

iv.) straightforward ideas that are easily transmitted to support consensus-building,

v.) ideas that generate the least opposition,

vi.) a path that does not require the complete re-organization of society and offers broad options towards society's new endpoint,

vii.) a potential for evolving the current economic paradigm into one adapted to existing and future scarcities, and

viii.) an assumption that economy is subsumed by environment, a perspective that must be applied to all scales in the system under consideration.

The last point should be stressed here, as the authors go on to say that people must understand how an individual's actions contribute to a cumulative effect and how changing one's own behaviour moves society collectively towards the sustainability goal.

In the view of Robèrt and colleagues, the key to any sustainable development model is that it rests solidly on a scientific foundation. Economists struggle to internalize environmental costs and the use of "margin-based valuation" of environmental costs fails to recognize the systemic nature of some problems, the complex interrelationships in ecosystems, and that many environmental effects are not linear, but can for instance be threshold-based (Robèrt et al., 1997: 80). Since the authors assert the moral basis for sustainability is the continuation of nature for its own sake (Robèrt et al., 1997: 79), this means economists must presuppose the biophysical conditions that ensure the survival of the biosphere are sacrosanct and build into models a suite of feedback mechanisms (indicators) that track the movement of society vis-à-vis its sustainability goals (Robèrt et al., 1997: 80, 81, 83).

A Canadian context can be illustrated by the six "key principles" of SD as promulgated for the main sectors of the economy, explicitly including agriculture and food, by the 1991 Ontario Roundtable on Environment and Economy (Lonergan, 1993: 336). First, intergenerational equity means the stock of natural and human capital must be non-declining over time and essential ecological services must remain intact. Second, environmental, social and resource depletion costs are internalized; the polluter pays principle is invoked. Third, a pro-active, rather than reactionary, stance is taken. Where structural analyses of the socio-economic system expose sources of pressure from individuals (consumers), businesses or institutions, action is taken to anticipate the cumulative effects and put in place preventative measures. Fourth, fully-informed decision making is important. All stakeholders are empowered in a decentralized, consensus-based model of decision-making. Fifth, depletion of non-renewable resources should be offset by increasing technological efficiency, closing the loop for material use, and the development of finite-resource substitutes for use by future generations. Sixth, quality of development is preferred over quantitative expansion. Consumers are made aware of the impacts of their choices, while product durability, energy efficiency and "a more efficient spatial distribution of activities" and presumably their by-products is stressed for the wider socio-economic system (Lonergan, 1993: 336-337).

The AEI in use by AAFC are modelled on the driving force-state-response (DSR) framework developed in part by the OECD from original Canadian efforts (Berger & Hodge, 1998: 256; Dumanski & Pieri, 1997 ¶4, #2; Smith & McRae, 2000: 2). The DSR model has been adopted by agencies of the United Nations and many nations to structure indicator development at discrete scales in a manner compatible with a hierarchical view of agroecosystems (e.g. Conway, 1985: 34). This is the "hard systems view" of agriculture, viewing agroecosystems as repairable mechanisms, where pressures of frequently human origin are identified within a defined boundary, e.g. field or farm, and the state of the system is observed, usually with the notion that outcomes of the pressure are undesirable (Walter-Toews, 1996: 686-687). The responses of various actors within the system may then be prescribed in order to effect positive change in the pressure variable, thus setting up a cycle of continuous feedback between humans and the environment (Guy & Kibert, 1998: 41). Figure 2.1 shows the Canadian variation, driving forces-outcomes-responses, and some of the functions and elements within each category as set out by Smith and McRae (2000: 2) in the initial AEI development.

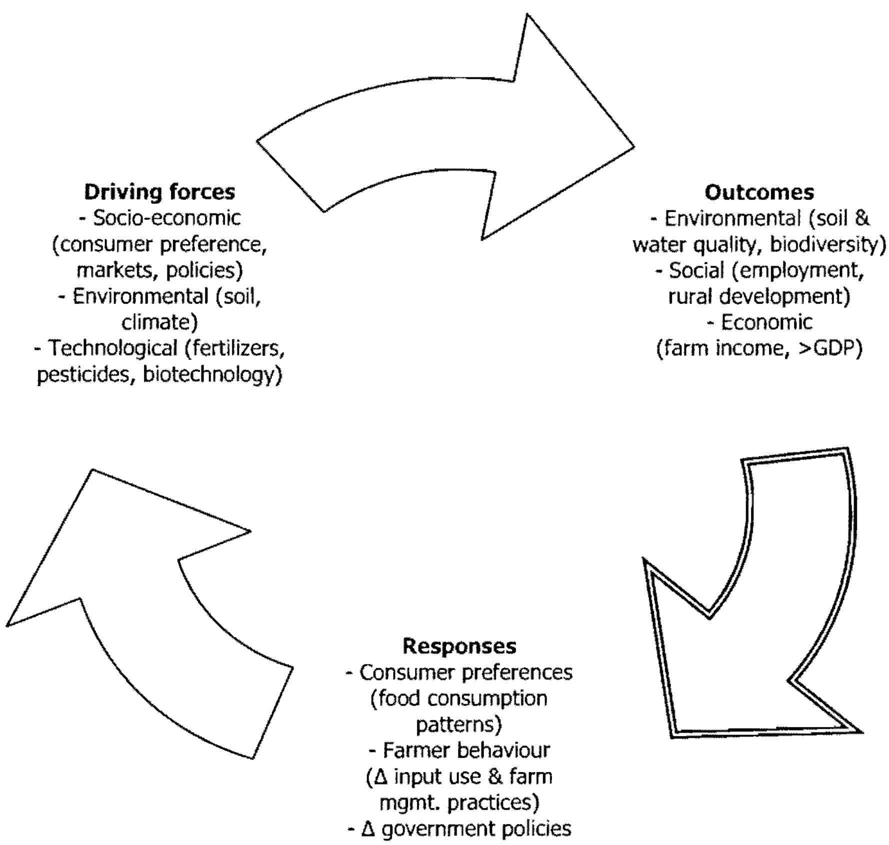

Figure 2.1: Driving force-outcome-response framework framing Canada's AEI (After Smith & McRae, 2000: 2).

As figure 2.1 illustrates, consumer preference is both a driver of agri-environmental change and an appropriate target for response options. The highlighted arrow between outcomes and responses denotes the typical placement of indicators (Guy & Kibert, 1998: 41, figure 1). AAFC currently does not explicitly propose indicators that infer consumer preference responses to agroecosystem pressures originating from socio-economic driving forces (see table 1.1) (Lefebvre et al., 2005).

2.4 Sustainability indicators

Providing a connection that is meaningful to citizens, policy-makers or educators between activities and their consequences is often done by means of indicators. Indicators are specific measures of environmental, social or economic health that serve as proxies for the overall state of the system, usually with the view of ensuring the system's continuing integrity and sustainability (Maclaren, 1996: 186). Although the complexity of information imparted by an indicator should coincide with the level of understanding of the intended audience, including non-scientists (van den Bergh & Verbruggen, 1999: 62), in all cases the primary usefulness of indictors is as a communication tool to "simplify a complex reality" (Smeets & Weterings, 1999: 5). To be useful they must describe key aspects of the system in question, rather than characteristics that are "superficial or isolated" (Moxey, Whitby & Lowe, 1998: 265). Further, measureable changes in the states, values or direction of movement of indicators must reflect concomitant changes in the system (Moxey et al., 1998: 265). These criteria have been addressed since the initial development of Canada's agri-environmental indicators (Lefebvre, 2005: 3).

In essence, an indicator is a specific measure or statistic about a system that infers a behaviour that is hard to observe directly or describes a change in state, condition, or quality of the system (OECD 1993, in Dumanski & Pieri, 1997: ¶9; Rigby, Woodhouse, Young & Burton, 2001: 465). Hansen (1996: 134, table 5) argues that policy-makers need indicators of agricultural sustainability that:

- take the literal view of sustainability: the ability to continue through time;
- are objective properties of the system, rather than a series of prescriptive elements that must be realized for a system to be sustainable;
- are continuous variables that allow comparisons between states or systems;
- enable the description of a future state, not simply the present or past states, and incorporate measures of variability; and
- classify and rank limitations (to sustainability).

Indicators ideally relate environmental, social, and economic issues that may only be apparent at a local scale, to the regional or national scale at which the appropriate political decisions are made (Haberl, Wackernagel & Wrbka, 2004: 194; Robèrt et al., 1997: 80). Their use has become increasingly prevalent in countries, notably Canada, where research into sustainable agriculture has lead to a concerted effort for their development and use (Smith & McDonald, 1998: 22). Many indicators of sustainability have been implemented to characterize certain portions of larger systems, sometimes with the intent to obscure negative practices or avoid politically unpalatable choices (Pearce 1998, in Rigby et al., 2001: 465), but also oppositely to break complex systems into more manageable units for clearer analysis (Costanza & Patten, 1995: 195).

Land quality indicators (LQI) are derived from the application of the DSR framework to measure the biophysical characteristics of land, the effects of land management practices, and the socio-economic conditions that contribute pressures and constitute the policy environment within which responses can occur (Dumanski & Pieri, 1997: ¶18). With respect to LQI, the quality of land is its instant condition in relation to the expectations of it for a specific use, here agriculture. Land is not only soil, but landscape, climate, flora and fauna, surface- and groundwater, and augmentations that facilitate agriculture, like drainage works and terracing (Dumanski & Pieri, 2000: 94).

When, as is frequently the case, expert, *a priori* identification of important system functions forms the basis for indicator development, an iterative process often occurs whereby the indicator is "molded" (sic) to conform to available data (Dumanski & Pieri, 2000: 95). The danger in this is that rather than measuring system trajectory in relation to defined sustainable development goals (the desired state), the indicators can instead become predictions about the efficacy of responses to alter the driving forces (figure 2.1) (Costanza & Patten, 1995: 194). The LQI were instead developed after "comprehensive analyses of the complex systems to be described and monitored" (Dumanski & Pieri, 2000: 95).

There is a class of indicators that appraises the relationship between human demand for ecosystem goods and services and the Earth's ability to supply them, or carrying capacity (CC), as defined in the introduction on page 9. Of more interest are CC indicators related to land area availability, rather than yield from the land, which for modern agri-food systems is dynamically dependant on climate, input and pesticide availability, advances in bioengineering and biotechnology, and the lowered resilience of monoculture agroecosystems (Plucknett & Smith, 1986: 40).

Nonetheless notably, in 1986 a direct connection between land area and yield was made in attempt to ascertain CC as the "human appropriation" of photosynthetic products (Vitousek, Ehrlich, Ehrlich & Matson, 1986). Drawing together the best estimates of net primary productivity (NPP), the biomass remaining after the plant's own respiration, maintenance and reproductive needs have been met, of the surface, sub-surface and aquatic environments from available literature, the authors' calculate it at 225 petagrams of carbon (Pg = 10^9 tonnes) (Vitousek et al., 1986: 369, table 1).

Three estimates for usage of NPP for five billion people were made. The low estimate includes only biomass directly consumed as fuel, food, timber and fibre. The intermediate estimate accounts for the productivity of all agroecosystems, rather than just the consumed elements, and activities like using fire to clear land. Finally, the high estimate also includes productivity lost as a result of land use changes, like urbanization, and that lost as a consequence of agricultural mismanagement, for example to desertification and erosion; the high estimate is the one favoured by the authors (Vitousek et al., 1986: 368).

Acknowledging that errors are likely for global estimates such as theirs, Vitousek and colleagues nevertheless state the results "accurately reflect the magnitude" of human appropriation (1986: 372). They find, as a proportion of terrestrial land, some 40% is co-opted for human use and the remainder likely suffering considerable impact; because human use of marine ecosystems constitutes a small fraction of its NPP over a wide area, adding the aquatic appropriation lowers the fraction to about 25%. Although the methodology accounts for the crops grown and used in a single year and could thus provide insight on a smaller scale, it does not suggest the distribution of NPP usage and cannot connect domestic supply and demand for agricultural products (Vitousek et al., 1986: 368; 372, table 4).

As humans can use technology, import energy and food, and export waste and by-products, purely ecological estimations of CC useful for animal populations are inappropriate (Rees, 1996: 196). Cohen reviewed six methods acceptable for calculations of human CC, leaving aside "those that are categorical assertions without data" (1995a: 342).

i.) Divide the world into regions defined by the differences in their maximum supportable population densities; multiply density by regional area and sum all regions. This was done by several geographers using fixed density estimates that were not objectively derived.

ii.) Fit mathematical curves to historical population trends and extrapolate to future population estimates. Since the forces controlling birth and death rates have remained elusive, the rationale for fitting the curves in any particular way is suspect.

iii.) Assume a single constraining factor and calculate maximum human population based on that limit. This lends itself to simple mathematical formulae, for example maximum population = total food supply/individual food needs. This method may be hard to justify because it assumes no other forces or factors will intervene.

iv.) An expanded variant of iii), above, combines multiple constraining factors into a single index; for instance, land area required to provide food, fibre and fuel. The same difficulty justifying constraining factors, also in iii), applies here too.

v.) Rather than an index, several independent factors are modeled as constraints. For example, the simple food equation from above can broken down into food groups, and water or input supply calculations can be introduced. From the various maxima, the smallest is chosen as the largest supportable population.

vi.) Combine several independent factors into large computerized sets of difference equations. The functional relationships between human populations and limiting variables, and the interactions

> between the variables themselves are often assumed and are difficult to quantitatively test.
>
> (Cohen, 1995a: 343-344).

Methods one through five are "deterministic and static" and vulnerable to assumptions about changes in variables and dynamism in the relations between them. The stochastic model implied by method six has been applied on a regional scale and is a good candidate for global modelling if only the enormous number of variables, from climate change to epidemics to ocean temperatures, can be reconciled (Cohen, 1995a: 343).

William Rees defines human carrying capacity as the maximum environmental load that can be sustained "without progressively impairing the productivity and functional integrity of relevant ecosystems wherever the latter may be" (Rees, 1996: 203). As opposed to CC describing the maximum supportable population, he asks the proper question: what area of productive land, irrespective of geographic location, is required to support a specific population, at a given technological level and standard of living (Rees, 1996: 203)? This methodology gave rise to an indicator of CC called the ecological footprint (EF), which was developed by Rees and his student Mathis Wackernagel (Wackernagel & Rees, 1996: 9).

The EF is a determination of the flow of material and energy in a socio-economic system expressed as the number of hectares of land globally-averaged for bioproductivity required to support it (Erb, 2004: 247). The EF is a representative calculation of all the human goods derived from nature, the wastes and by-products deposited there, and the ecosystem functions impacted, simplified for data management purposes. The generalized procedure involves:

- Assuming industrialized harvesting of ecosystems, namely forests and agroecosystems, is sustainable. This leads to conservative estimation since overharvesting is often the case.
- Including only "basic services of nature" to start, with additions to be made as time for development permits. The original services considered are rate of renewable and non-renewable resource use, capacity for waste absorption, and urban land use change.
- Considering areas for only a single use to avoid double-counting. The use for which an area is accounted is the one with the largest impact.
- Using eight land categories to represent all the ecosystems on Earth.

(Wackernagel & Rees, 1996: 61-62).

Using aggregate national or sub-national data for production and trade for five main classes of economic activity, food, housing, transportation, consumer goods, and services, and dividing by the contained population provides estimates of individual consumption of goods and services. Dividing these statistics by yield or productivity rate leaves as a remainder the per capita area required to support this consumption. More complex industrial goods, like apparel or automobiles, may need step-wise disaggregation to reveal the final area of production. The sum of these individual areal requirements is the EF for a single person to which a factor can be applied scaling it up the desired level of interest, from individual through to national (Wackernagel & Rees, 1996: 63-67).

The areal estimates are not straight-forward geospatial quantities; rather, they are additive portions of eight conceptual land uses "embodied" in the consumption of the product that fall into one of four general classes:

i.) Energy land is assigned based on the amount of forested land required to assimilate the 1t of CO_2 emitted by the generation of 100 gigajoules of energy from fossil fuel sources, 1.8 hectares.

ii.) Consumed land includes built-up land that is paved over, eroded lands, or those otherwise lost to bioproductive use through human activity.

iii.) Currently used lands are gardens, crop lands, pasture, and managed forests that supply food and fibre needs.

iv.) Limited lands are areas remaining in relatively natural states that should be preserved.

(Wackernagel & Rees, 1996: 68, table 3.1; 72-73).

For any given product or service, a matrix is constructed allocating the analyzed consumer items under the five general economic headings to the eight land types used. The total area determined in this way is not a fixed area of land, but that expropriated from the ecosystems around the world that supplied material, energy, or waste sinks to the final products (Wackernagel & Rees, 1996: 82-83, table 3.3). The real strength of this sustainability indicator is a product of its use of relatively common data, the easy calculation, and perhaps most importantly the comparability of results (Erb, 2004: 248). Discussions generated by the authors include calculating the EF for the world's population at North American standards of living and determining the EF for several countries and the world and comparing them. In 1991, the global EF was found to be 1.8ha, while that of an Indian citizen was 0.4ha; an American, 5.1; and a typical Canadian, 4.3 (Wackernagel & Rees, 1996: 85, table 3.4; 88).

The EF can be applied to specific industries in defined areas, and then later apportioned to multiple actors within or without the system as a way of allocating CC. Increasingly liberalized global trade simultaneously detaches people from first-hand knowledge of the degradation their consumption causes while ironically increasing their vulnerability to the effects of those impacts. By investigating discrete sectors of the economy, an allocation of environmental loads posed by imports and exports can be made (Kissinger & Rees, 2009: 2309).

Kissinger and Rees (2009: 2310) combine material flow analysis, a method for indentifying the types, quantifying the amounts, and tracking the progress of material and energy through a defined system, with EF analysis to study the agricultural system of the Canadian Prairies. Specifically, they want to know the share of agro-ecosystem products and services embodied in the export of 22 products in 6 categories, grains, legumes, oilseeds, root crops, animal feeds, and animal products, as a time series from 1989 until 2007. Further, they track the fraction of the total export footprint to each of five importing regions around the world (Kissinger & Rees, 2009: 2311; 2314, figure 4).

Their method takes the following steps: identify and quantify Prairie agricultural products and the share of those for export, determine the "key inputs" used in the agri-food system, and estimate the land area required both for production and for sequestration of the CO_2 attributable to it. Using food availability data (i.e. the apparent disappearance of food), the researchers translate processed agri-food products into their basic ingredients through US Department of Agriculture conversion factors and the FAO's technical conversion guide. They assign actual land areas based on the fraction exports represent of the total production for each commodity. Likewise for assigning a share of the energy (and then CO_2 land) used to supply the total water, pesticide, fertilizer inputs to the system (Kissinger & Rees, 2009: 2311; 2311, footnote 4).

The study reveals the production of 22 commodities considered required the support of over 55 million bio-productive hectares of land, the total ecological footprint for the system. Of that, just over 51% was exported, averaged over the study period. Broken down, the export share of the EF ranges from 72.5% embodied as grain exports, to 39.5% for beef cattle. By region, 37% of the Prairie agricultural EF went to the US, 26% to Asia, and 11% to Latin

America, with the remainder going to the EU and "other countries" (Kissinger & Rees, 2009: 2312-2313; 2313, table 2).

The popularity and subsequent usage of the EF method is such that the term "footprint" has entered the vernacular, but it is not without its detractors. The method of aggregation used in the calculation, often billed as a strong point, makes it difficult for an individual or policy-maker to decide which aspect of a system is unsustainable (van den Bergh & Verbruggen, 1999: 63). The aggregated EF areas may need to be complemented with real areal requirements and the availability of that land to properly determine sustainability (Erb, 2004: 248). Additionally, related still to aggregation methods, it is hard to choose responses at the regional or national scales that are based on pressures felt at the local scale because while the EF observes ecological tenets and thermodynamic laws, it lacks a weighting scheme for social factors (van den Bergh & Verbruggen, 1999: 64). For example, the different abundances of renewable energy supplies across Canada may not be accurately reflected if a national decision is taken to reduce fossil fuel use to reduce the country's EF. This is not trivial, since van den Bergh and Verbruggen (1999: 65) assert over 50% of developed nations' EF derives from the use of fossil fuels.

An adaptation of Wackernagel and Rees' (1996) indicator relates a nation's EF to its domestic biocapacity in a time-series analysis. This variant attempts to capture imported goods in domestic land use estimations, which is especially useful for products a country may not be able to grow or produce, by incorporating "complimentary" data about actual land availability and its spatial distribution (Erb, 2004: 248). In applying his method to Austria, Erb analyzes each component of national apparent consumption by dividing country-specific yields into domestic production, imports, and exports to derive real areas that he then assigns domestically to the land classes accounted for by the EF method. Taking agriculture as an example, Erb creates a 207-country list of yields for 61 products, including 39 primary products (crops), that he assigns to Austrian pasture land and arable land (Erb, 2004: 249-250).

Since the productivity of Austrian land is higher than the global average, the areal demand based on this method is lower by half than the conventional EF analysis (Erb, 2004: 253-254). Using country-specific yields also unmasks other possibly counterintuitive results, such as the declining share of per capita pasture land required to provide meat, milk, etc., in the face of a constant rate of consumption owing to yield increases. Erb asserts the simple summation of shares of land globally-averaged for productivity results in the loss of "huge amount[s] of information" contained in, say, the mix of yields within a particular nation's trading partners or the qualitative differences in soils requiring different amounts of irrigation or input use. Neither the conventional EF nor Erb's modification assesses sustainability, but in using real, spatially-assigned areas the latter method can be integrated into an indicator framework (2004: 255).

Cowell and Parkinson (2003: 221-222) recently presented a method to examine the ability of only local areas to satisfy the consumption requirements of the United Kingdom. The authors observe that the globalization of the agri-food sector could be seen as a benefit to society by inducing wider competition and thereby lowering prices and broadening consumer choice or as a disbenefit by reducing countries' food security (self-sufficiency) and masking environmental and social harms caused by exploitative practises in places far from final consumption. By contrast, localisation, defined as domestic production, is seen as a way of at least illuminating the negative aspects of agricultural production and reducing the transportation-related impacts of importation. In part, their purpose is to assess the possibilities for localising production, since they note there is no point to policies advocating localisation if it is infeasible.

Land area is chosen as an indicator because increasing populations lead to increased competition for use of this finite resource and because consumption within these populations is generally increasing. They deem the country level appropriate because in the UK, as in Canada, agricultural policy is mostly driven by the central government. Their method uses actual data on specific food groups, rather than the grain-equivalents or estimated consumption levels of other studies, which allows "more detailed insights" into the effects of a localisation strategy and avoids criticism over data accuracy (Cowell & Parkinson, 2003: 224).

Working with 1992 aggregate national data in mass units, Cowell and Parkinson (2003: 225) begin by determining consumption as the residual after adding production and imports and subtracting exports and changes in stock (i.e.

the apparent disappearance of food). They apply often complex formulae to work from homogenous bulk government and industry agri-food statistics (e.g. tonnes of beef) back to the land required for food crops and for the farmland that supported the consumed animals' lifecycles. Dividing the various consumption quantities by their respective yields leaves the area required for production (Cowell & Parkinson, 2003: 226-227; 234-235). For food not producible in the UK the authors propose to substitute an "average mix" of similar products without offering details as to its derivation (i.e. by the mix of current areas of production, as proposed here, or similarly by production masses) (226). They do not allow for differences in production practises, which is especially notable for localising foods like livestock under intensive production (227).

The ratio of production to consumption gives Cowell and Parkinson a "self-sufficiency index," which they use only to assess the UK's relative reliance on imports for any given food category (2003: 225; 227, table 2). Because part of their method involves calculating tonne-kilometres for energy use analysis, they use mass units for this ratio (2003: 225). Since the index is unitless only the magnitude of (in)sufficiency can be understood and not quantitative differences. The area currently under cultivation for each food category is compared with that required under a localisation policy revealing that animal products take the most area by far, requiring as much as eight times more land than the next category, cereals. In total, the UK requires between 1% and 16% more agricultural land than it has to supply its consumption and Cowell and Parkinson conclude that in order to meet a localisation strategy, meat consumption must be drastically reduced or plants with significantly higher yields must be substituted for those currently produced or both. They point to UK survey results showing strong preference for locally produced fruits and vegetables and growing vegetarianism and suggest consumption patterns could shift in what is for them a positive direction (Cowell & Parkinson, 2003: 230-231).

Researchers from the Netherlands have reviewed food security studies and projections of future demand and note that most assume a constant supply of land despite the fact that arable land is being lost at the rate of 7% per decade. The green revolution has led to the juxtaposition of increasing per capita grain harvest and declining per capita arable land. The land required for food however is dependant on more than just yields and production methods, because of shifting consumer demand for different types of food. This gives rise to areal quantification based on food consumption patterns, which are observable trends in the types and combinations of foods eaten by a given population. These patterns are influenced by culture, religion, personal tastes, food availability, and habit, amongst other things, and can shift over time in the same place. Since an "affluent" diet including animal-based products may require three times the land of a vegetarian diet, the effects of shifting consumption patterns on land requirements are likely of the "same order of magnitude" as the combined effects of rising population and changing productivity (Gerbens-Leenes, Nonhebel & Ivens, 2002: 47-48).

Gerbens-Leenes and co-workers note that circumstances must be clearly defined for analyses of land requirements because significant differences in consumption patterns occur between nations and because the kinds and quantities of foods grown and the consequent environmental impacts are a result of a close interdependence between agri-food supply and consumer demand (2002: 48). They state the use of household consumption data ("the bottom of the food system") represents a substantial advancement in the quality of land requirement analyses (Gerbens-Leenes et al., 2002: 48).

The method begins with 1990 household expenditure data, rather than with physical quantities, for over 100 foods commonly eaten at home by the Dutch in nine categories. Quantities are derived by applying price data directly (i.e. purchase amount times physical units per unit cost) or via the results of a previous Dutch study describing the relationship between price, nutritional energy, and physical quantity. Processed foods are rendered to constituent ingredients through technical conversions and industrial recipes. For domestically-producible crops, the inverse of the weighted average yield gives area requirement as m^2/kg. For imports, the origins and amounts of products are determined and the inverse of the yields provided by the FAO are applied. Livestock products, here also excluding fish, are grouped into intensive animal production and dairy farming; animal feed statistics are used to find pasture, fodder, and roughage areas. Breaking raw milk down into its constituent carbohydrate, protein, and fat components according to fraction of nutritional energy, the area required for each is found; the area required for dairy products, for instance cheese and yoghurt, are found based on the composition of those milk constituents. The sum of the household land area requirements is multiplied by the number of households to give national area needs (Gerbens-Leenes et al., 2002: 50-52).

The results reveal Dutch household consumption is dominated by meat and dairy products and the area required to supply them represents 47% of the total household requirement, compared to 12% for fruits, vegetables, and bread. The effects of diet affluence are illustrated by noting the addition of "one mouthful (10g)" of meat everyday by an individual increases area requirement by about 100m^2, while the same increase in potato consumption increases area by a mere 2m^2 (Gerbens-Leenes et al., 2002: 53, table 2; 54). The Netherlands government also calculates national food availability (apparent disappearance of food) and the authors apply their method to this quantity for comparison. They find congruence between their own results and governmental estimates, asserting this validates the assumptions made in the course of the work (Gerbens-Leenes et al., 2002: 55).

3.0 Methods

Since assessing national self-sufficiency for major food groups is the goal of this study, demand must be expressed in terms that are comparable to those of supply. The subsequent analysis is premised on the work of Cowell and Parkinson (2003), especially their reporting of the real national land areas that would be needed to supply domestic food consumption and comparison to existing areal capacity. Also like their work and that of Gerbens-Leenes and colleagues (2002) and Kissinger and Rees (2009), this study uses commonly available government, technical, and industry information (e.g. FAO, n.d.; StatsCan, 2009) to relate the original masses of primary agricultural products to their processed counterparts. However, unlike Cowell and Parkinson and studies based on the EF methodology (Erb, 2003: 247) that use the apparent consumption of food and resources as the basis, the method employed here begins with surveyed consumption (StatsCan, 2003b).

Total Canadian food consumption is determinable by the following process. The 2001 Food Expenditure Survey (FES) (StatsCan, 2003b) estimates food expenditures and quantities for the over 11.5 million households (StatsCan, 2005a). These are listed as household weekly averages for 195 different broad food groups, like cuts of beef, fresh apples, and jams and preserves, which are in turn aggregations of almost 2000 individual types of food or brand names (StatsCan, 2003b). StatsCan lists these foods broadly into the following groups:

- Meat (including meat preparations)
- Fish and other marine products
- Dairy products and eggs
- Bakery and other cereal products
- Fruits and nuts (including fruit juices, jams, etc.)
- Vegetables (including vegetable products and juices)
- Condiments, spices and vinegar
- Sugar and sugar preparations
- Coffee and tea
- Fats and oils
- Other foods, non-alcoholic beverages, food materials & preparations

The survey was administered as two, one-week diaries completed by 5,643 urban and rural households in all Provinces, as well as households in the cities of Iqaluit, Whitehorse and Yellowknife; as not all households completed both, the sample comprises 11,034 diary-weeks for a response rate of almost 98%. This is the eighteenth such survey to be completed since they began in 1953, the sixth in a row to include smaller communities and thus claim to be nationally representative. The stated "primary reason" for conducting the survey is as an economic tool to help adjust the consumer price index, but other reasons include market analysis and nutritional studies (StatsCan, 2003b: User Guide, 4). The User Guide states the samples are weighted so that the detailed food list reflects differences in "sampling and response rates among geographic areas and household types," but gives no further details (StatsCan, 2003b: User Guide, 11). There are six appendices to the survey that list statistical information like frequency counts or provide data summaries; Appendices C(ii), detailed quantities, and E, food codes, are useful here. The former contains the values transformed by the method, while the latter provides complete details of foods in all categories and is included herein as Appendix 1 (StatsCan, 2003b).

Multiplying the number of households in Canada in 2001 by the average quantities consumed per week as found in the FES gives the national consumption for each foodstuff. These weekly values are then transformed into yearly amounts, which may be in metric mass or volume units, like kilograms of apples or litres of strawberries, and thus directly usable, or shown as quantities that need further transformations. For those food items reported as a number consumed, for instance the number of ears of corn eaten (StatsCan, 2003b), an equivalent measure in the appropriate metric units is found using accepted technical conversion factors.

The 2001 Canadian data for field crops, fruits and vegetables, data regarding animal feed requirements and other information are obtained from governmental resources, predominantly from Statistics Canada's Canadian Socio-economic Information Management system (CANSIM) II database (2009) and Agriculture and Agri-food Canada (AAFC), as well as the United Nations Food and Agriculture Organization (FAO). These quantities are often in imperial measures, likely reflecting farmers' usage, and must be converted; conversion factors are utilized where required (StatsCan, 2002: 11).

Some foods cannot be produced in Canada due to climatic or geophysical factors. In the case of items such as tropical fruit, a representation of Canadian-produced fruit is established and substituted (Cowell & Parkinson, 2003: 226); likewise for rice or other staples not appreciably produced in Canada. Aquaculture was not included in Cowell and Parkinson's study because fish farms "do not occupy terrestrial land areas" (2003: 227). However, farmed fish are fed from terrestrially-grown grains (StatsCan, 2005b), and the industry exists in all provinces and Yukon and Northwest Territories (AAFC, 2003). Therefore, the feed requirements are calculated to meet the household consumption averages (StatsCan, 2003a) with substitution made for non-farmed fish by the major farmed fish in Canada, salmon (see 3.1.2, below).

Studies that refer to national production data to estimate areas dedicated to domestic food consumption or to calculate the EF of food utilize categories based on sectors of primary agricultural production, including, for example, meat, vegetables, fruit, and cereals. Because such studies begin with bulk agricultural materials they account for all end uses regardless of the degree of subsequent processing (Cowell & Parkinson, 2003: 225, table 1; White, 2000: 151). Studies examining environmental impact from the consumption perspective can examine prescribed diets. The life cycle assessment of the "predominantly plant-based Mediterranean diet" on which recommended nutrition guidelines for the US and other nations are based is an example (Duchin, 2005: 104). As the method here is applied to Canada and uses a consumer survey that is akin to a dietary estimation, only foods suggested by Canada's Food Guide (Health Canada, 2008a: 1) will be included in the study. Thus, for nutritionally non-essential items that cannot be grown in Canada, such as cocoa, tea and coffee, no substitution will be made. Likewise, no accounting will be made for other foods such as ice cream, sweets and cakes.

3.1 Reconciling quantities in the FES

The explanation of the method generally follows the numerical order of the food codes. As noted, the detailed food codes and descriptions are found as Appendix 1. The FES Appendix C(ii) reports results in an electronic spreadsheet to at least two (2) significant figures, the same number as the conversion factors and yields (StatsCan, 2003b; 2009). Although the numbers were not rounded in the model for the calculations, they are reported here rounded simply to three whole numbers; more than three significant figures is not implied.

3.1.1 Meat (including poultry)

In the FES meat is given as kilograms consumed per household for the various primal[5] cuts of beef, including hip, loin, rib, and chuck cuts, and of pork, including leg, loin, belly, and shoulder cuts; lamb, mutton and other animal meats and chicken, turkey and other poultry meats are not sub-divided according

[5] The edible portion of an animal (not poultry) is prepared by cutting the eviscerated carcass in half lengthwise through the spine and subsequently each half into four or more primal cuts from which serving-sized portions are prepared (Potter & Hotchkiss, 1998: 317).

to cut (StatsCan, 2003b). In the case of beef and pork, these cuts must be aggregated into their equivalent whole animals to determine necessary grazing land. Farm animals slaughtered for meat are valued on the basis of the edible portion, usually called cold dressed weight or dressed carcass weight (DCW) when the meat is ready for sale; this is the fraction remaining after removal of the hide or feathers, head, blood, feet and guts (Government of Alberta, 2008).

For beef Potter and Hotchkiss (1998: 331-332, figure 14.11) provide a reference for approximate yields from a dressed beef carcass. Table 3.1 reproduces their summary table showing common wholesale beef cuts and the corresponding percent share of a carcass; where it differs, the term for a cut as used in the FES is provided in brackets (Appendix 1).

Table 3.1: The approximate yield of typical cuts of beef from a dressed carcass.

FOREQUARTER CUTS	YIELD %*	DCW (KG)	HINDQUARTER CUTS	YIELD %	DCW (KG)
Chuck	26	91.7	Round (Hip cuts)	23	81.1
Ribs	9	31.8	Sirloin (Loin cuts)	9	31.8
Fore Shank (Other beef)	4	14.1	Short loin (Loin cuts)	8	28.2
Brisket (Other beef)	5	17.6	Flank (Other beef)	5	17.6
Short plate (Other beef)	8	28.2	Offal	3	10.7
Total	52	183.4	Total	48	169.4

*Source: (Potter & Hotchkiss, 1998: 331).

Also shown, in order to estimate the number of cattle accounted for in the FES, are the yield percentages applied against the average DCW for Canadian cattle for 2001: 352.8kg (StatsCan, 2009: survey 003-0026). The average mass yields for each cut of meat are divided into the corresponding yearly quantities of those cuts from the FES to give the number of animals that would have been slaughtered to provide each cut; the largest number is used. However, there are several steps taken in advance of the final result.

Beef is unique in the FES as the only meat for which "ground" is a special category (Appendix 1). Potter and Hotchkiss state it is derived from every cut, but not from offal (1998: 332). Therefore, the quantity of ground beef will be distributed against the respective cuts after the yields from table 3.1 have been re-weighted to remove the 3% offal from the calculation. The offal is treated later as a stand-alone category.

Several categories of prepared foods containing products made from different animals are listed in the FES; among others, these include sausages, canned meats, ready-to-eat items, and restaurant take-out foods. Where the FES category contains items made from the meat of different animals the quantity will be distributed according to the preference for each meat in the FES. Bologna is made entirely from ground beef and is added there (Potter & Hotchkiss, 1998: 327; Appendix 1).

Table 3.2 shows the portions of prepared, cured and canned meats, and sausages that are made from almost 160,000 tonnes of ground beef. The total mass from table 3.2 is added to the total ground beef, which is then allocated to the cuts shown in table 3.1 after re-weighting to exclude offal. The re-weighting is shown in table 3.3 and the ground beef calculations in table 3.4.

Table 3.2: Share of listed categories supplied by ground beef.

FES CATEGORY	MASS OF GROUND BEEF (KG)
Other cured meat	2,500,000
Uncooked sausage	25,200,000
Bologna	17,900,000
Wieners	20,000,000
Other cooked or cured sausage	37,800,000
Other ready-cooked meat	32,400,000
Other meat preparations	7,490,000
Meat stews and hams	8,410,000
Other canned meats (...)	6,940,000
Total	159,000,000

Table 3.3: Ground beef allocation table.

CUT	% (TABLE 3.1)	RE-WEIGHTING
Round	23.0	23.7
Ribs	9.0	9.3
Sirloin & short loin	17.0	17.5
Foreshank, brisket, short plate, flank	22.0	22.7
Chuck	26.0	26.8
Total	97	100

Table 3.4: Allocation of ground beef to specific cuts.

CUT	RE-WEIGHTED %	MASS (KG)
Ground beef from FES		203,000,000
Addition from table 3.2		159,000,000
Sub-total allocated to cuts, below		362,000,000
Hip cuts	23.7	85,800,000
Rib cuts	9.3	33,600,000
Loin cuts	17.5	63,400,000
Other beef cuts	22.7	82,000,000
Chuck cuts	26.8	97,000,000

Once the weight of ground beef has been re-proportioned, it is added to the starting FES consumption for the respective cuts. This constitutes an addition of between 47% for hip cuts and 84% for chuck cuts. Despite having a lower fraction of the DCW than chuck cuts and the lowest addition of ground beef mass, the consumption of hip cuts is still the highest and requires the slaughter of over 2.23 million cattle. The FES cuts, 2001 consumption amounts, additions from table 3.4, mass per cut as a fraction of the 2001 DCW from table 3.1 and number of animals required to provide the total for each cut are shown in table 3.5. The bold typeface indicates how many cattle were fed to support 2001 consumption.

Table 3.5: Calculation of required slaughter cattle.

BEEF CUT	FES CONSUMPTION (KG)	MASS FROM TABLE 3.4	TOTAL CONSUMED MASS (KG)	DCW MASS/ CUT (KG)	NUMBER OF ANIMALS
Hip cuts	95,500,000	85,800,000	181,000,000	81.1	**2,240,000**
Rib cuts	35,800,000	33,600,000	69,400,000	31.8	2,180,000
Loin cuts	23,900,000	63,400,000	87,300,000	60.0	1,450,000
Other beef cuts	23,900,000	82,000,000	106,000,000	77.6	1,520,000
Chuck cuts	17,900,000	97,000,000	115,000,000	91.7	1,250,000
Offal	11,900,000	0	11,900,000	10.6	1,130,000

Dairy cows must reproduce each year to perpetuate lactation. Female calves are generally kept to replenish the herd, while males are slaughtered when they reach 205-318kg live weight to be sold as veal (Ontario Veal Association, 2003). Canadian grading regulations state the DCW of veal must be between 80-180kg (Department of Justice Canada [DOJC], 2009a). StatsCan (2009: survey 003-0026) found the 2001 average DCW for veal was 118.3kg. Unlike their parents, calves are not disaggregated into cuts in the FES (StatsCan, 2003b) so simply dividing the veal DCW into the FES average consumption gives the number of calves required. The FES cuts, 2001 consumption weights, 2001 DCW for veal and number of animals that were fed to support this consumption (bolded) are shown in table 3.6.

Table 3.6: Calculation of required slaughter calves.

MEAT	FES CONSUMPTION (KG)	DCW (KG)	NUMBER OF ANIMALS
Veal	11,900,000	118.3	**101,000**

Hog carcass yields are given in cold trimmed weight (CTW), the bled, eviscerated pig with the rear feet on and excess fat trimmed (for rendering, see section 3.1.7) (StatsCan, 2009: survey 003-0028, footnote 5). The average CTW for Canadian swine in 2001 was 83.6kg (StatsCan, 2009: survey 003-0028) against which the yield percentages are distributed. Approximately the same procedure is followed for pork as for beef using yield percentages obtained from Canadian Pork International [CPI], a producer, processor and exporter promoting organization. CPI and AAFC conducted a joint study in 1992 to determine yields of various cuts (CPI, n.d.) and those against the CTW the results are reported in table 3.7.

Table 3.7: The yield of typical cuts of pork from a cold trimmed carcass.

CUT	SHARE OF CARCASS (%)	CTW
Leg	27.6	22.6
Loin	24.7	20.8
Belly	23.9	20.1
Shoulder	23.8	20.1
Total	100	83.6

Source: (CPI, n.d.).

The FES has an "other pork" category that lists whole animals, sides and quarters that nominally follow the cuts from table 3.7; therefore, this quantity will be divided into the cuts from table 3.7 in proportion to consumer preference from the FES (StatsCan, 2003b). The 17,900 tonnes of other pork is allocated across all the pork cuts according to their fraction of the DCW shown in table 3.7. The distribution is shown in table 3.8.

Table 3.8: Share of selected categories added to pork cuts.

CUT	AMOUNT CONSUMED FROM FES (%)	MASS OF "OTHER PORK" (KG)
Loin cuts	73	13,100,000
Shoulder cuts	11	2,070,000
Belly cuts	8	1,380,000
Leg cuts	8	1,380,000

Pork used in sausages and prepared foods is typically from the shoulder cut (Manitoba Pork Council [MPC], 2004) and is added there. The application of the method to processed pork products follows the same process as for beef except, with the meat products and sausages apportioned to shoulder cuts according to table 3.9.

Table 3.9: Share of selected categories added to pork shoulder cuts.

FES CATEGORY	MASS OF PORK SHOULDER (KG)
Other cured meat	1,050,000
Uncooked sausage	10,600,000
Wieners	8,400,000
Other cooked or cured sausage	15,900,000
Other ready-cooked meat	13,600,000
Other meat preparations	3,150,000
Meat stews and hams	3,530,000
Other canned meats (...)	2,920,000
Total	59,200,000

Ham is derived from leg cuts and bacon is distributed to loin cuts and belly cuts according to the consumer preference for the two (MPC, 2004). Ham is apportioned to leg cuts as shown in table 3.10.

Table 3.10: Share of ham categories added to pork leg cuts.

FES CATEGORY	MASS OF PORK LEG (KG)
Ham (excluding cooked ham)	59,700,000
Cooked ham	30,000,000
Total	89,700,000

The weighting to apportion bacon is a simple 90:10 split between loin and belly cuts and is shown in table 3.11

Table 3.11: Share of bacon added to pork loin and belly cuts.

CUT	% SHARE	MASS OF BACON (KG)
Bacon (from FES)	100	41,800,000
Loin cuts	90	37,600,000
Belly cut	10	4,180,000

Pork cuts, 2001 consumption amounts, addition of values from tables 3.8, 3.9, 3.10, and 3.11, kg per cut as a fraction of the DCW from table 3.7, and the number of animals required to provide the total for each cut are shown in table 3.12. The bold typeface indicates the number of swine that were fed to support 2001 consumption.

Table 3.12: Calculation of required slaughter pigs.

PORK CUTS	FES CONSUMPTION (KG)	MASS FROM TABLES 3.8, 3.9, 3.10 & 3.11 (KG)	TOTAL CONSUMED MASS (KG)	DCW MASS /CUT (KG)	NUMBER OF ANIMALS
Leg cuts	11,900,000	91,100,000	103,000,000	22.6	4,550,000
Loin cuts	113,000,000	50,700,000	164,000,000	20.9	**7,860,000**
Belly cuts	11,900,000	5,560,000	17,500,000	20.1	861,000
Shoulder cuts	17,900,000	61,300,000	79,200,000	20.1	3,940,000

Lamb and mutton headline a category that includes goat, deer, buffalo, caribou, horse and rabbit meats as well as frog's legs (Appendix 1). As lamb and mutton are singled out and the distribution of other meats within the category is unknown, the StatsCan average DCW for sheep and lamb, 21.1kg, will be divided into the FES quantity to give an equivalent number of ovine animals (StatsCan, 2009: survey 003-0028).

Not as many prepared meats and sausages start with lamb or mutton as with beef, pork or chicken in Canada. Table 3.13 lists those FES categories apportioned in addition to the 2001 consumption.

Table 3.13: Share of listed categories added to lamb and mutton.

FES CATEGORY	MASS OF SHEEP (KG)
Other ready-cooked meat	939,000
Other canned meats (...)	201,000
Total	1,140,000

The quantities from table 3.13 amount to nearly 10% of the 2001 Canadian consumption of ovine meat. This is shown, along with the 2001 average DCW of sheep and the number of animals slaughtered to support the total in table 3.14. The bold typeface indicates the number of sheep that were fed to support 2001 consumption.

Table 3.14: Calculation of required slaughter sheep.

MEAT	FES STARTING MASS (KG)	MASS FROM TABLES 3.13 (KG)	TOTAL CONSUMED MASS (KG)	DCW (KG)	NUMBER OF ANIMALS
Sheep	11,900,000	1,140,000	13,000,000	21.1	**620,000**

In Canada chickens are slaughtered and mechanically processed at a rate of about 25000 broilers (meat animals) per hour (AAFC, 2008b), mainly in Ontario and Quebec where some 60% of production takes place (StatsCan, 2009: survey 003-0018). After being electrically stunned, killed by bleeding from the neck, scalded in hot water, and plucked of feathers, the birds are mechanically eviscerated, then cleaned and prepared for consumption whole or for further processing (Barker, Lankhaar & Stals, 2004: 94-96, 97-98). The average dressed weight for birds is not supplied directly by StatsCan, as it is for cattle and swine, but is found by dividing the individual Provinces' meat production by their respective number of birds slaughtered and taking the weighted mean as the National average. StatsCan suppresses data where it might identify the survey participants; due to this, no poultry data are available for Prince Edward Island (P.E.I.) or Newfoundland and Labrador, representing 2% of Canada's production (StatsCan, 2009: survey 003-0018).

Table 3.15 lists the percent share from each Province of the total National production, the carcass weights, and the final DCW. The Canadian average weight of a dressed chicken was 1.53kg in 2001. Chickens are used in a variety of prepared and cooked foods that are simply allocated to whole chickens according to this meat's share of consumer preference, as shown in table 3.16. Prepared chicken products add almost 17% to the total eaten by Canadians in 2001. Chicken consumption in 2001, the addition of prepared food, the calculated 2001 DCW for chicken and the number of animals required to support the total (bolded) are shown in table 3.17.

Table 3.15: Percent share of chicken production and average dressed weight, Provincially and Nationally, 2001 data.

AREA	SHARE (%)	AVERAGE DRESSED WEIGHT (KG)
Quebec	27	1.58
Ontario	32	1.57
Manitoba	5	1.41
Saskatchewan	3	1.40
Alberta	9	1.47
British Colombia	16	1.44
New Brunswick	3	1.54
Nova Scotia	3	1.52
P.E.I.	x	-
Nfld. & Labrador	x	-
National	98	1.53

Note: x = suppressed Source: (StatsCan, 2009: survey 003-0018)

Table 3.16: Share of listed categories added to chickens.

FES CATEGORY	MASS OF CHICKEN (KG)
Other cured meat	2,420,000
Wieners	19,400,000
Other ready-cooked meat	31,500,000
Other meat preparations	7,270,000
Other canned meats (...)	6,740,000
Total	67,300,000

Table 3.17: Calculation of required slaughter chickens.

MEAT	FES STARTING MASS (KG)	MASS FROM TABLE 3.16 (KG)	TOTAL CONSUMED MASS (KG)	DCW (KG)	NUMBER OF ANIMALS
Chickens	400,000,000	67,300,000	467,000,000	1.53	**305,000,000**

Turkey production data are also suppressed for P.E.I. and Newfoundland and Labrador, but since the missing data account for less than a tenth of a percent of National production (StatsCan, 2009: survey 003-0018), the discrepancy can be safely ignored in this case. Using the same method as displayed in table 3.15, the 2001 Canadian average DCW for turkeys is found to be 7.40kg (StatsCan, 2009: survey 003-0018). Turkeys are used in some prepared foods and the distribution of those is shown in table 3.18.

Table 3.18: Share of listed categories added to turkeys.

FES CATEGORY	MASS OF TURKEY (KG)
Other ready-cooked meat	5,170,000
Other canned meats (...)	1,110,000
Total	6,280,000

Turkey products from table 3.18 add just less than 10% to the total eaten by Canadians in 2001. Turkey consumption in 2001, the additional mass from prepared food, the calculated 2001 DCW for turkey and the number of animals required to support the total, in bold type, are shown in table 3.19.

Table 3.19: Calculation of required slaughter turkeys.

MEAT	FES STARTING MASS (KG)	MASS FROM TABLE 3.18 (KG)	TOTAL CONSUMED MASS (KG)	DCW (KG)	NUMBER OF ANIMALS
Turkeys	65,700,000	6,280,000	72,000,000	7.4	**9,720,000**

There are other commercially important birds produced in Canada, including geese, ducks, ostriches, emus, rheas and small game birds, like pheasants, raised for food (AAFC, 2009a). In the FES, the consumption category for these birds also includes the offal and livers from chickens and turkeys. Together they constitute about 0.8% of poultry meat consumed in 2001 and will not be considered further.

3.1.2 Fish and other marine products

Fish is an important part of Canadians' diet. Although in 2001 almost three times the pork, over three and a half times the chicken and well over seven times the beef were eaten (StatsCan, 2003b), fish are nonetheless important to this accounting because the global wild fish harvest has peaked, so aquaculture will be increasingly called upon to provide this food (AAFC, 2003). Salmon and other ocean fish account for the vast majority of fish consumed in 2001 (StatsCan, 2003b). When farmed, salmon are fed a pelletized diet that simulates a natural one of crustaceans and fish; since salmon are the most-farmed fish in Canada (AAFC, 2008c), it can be assumed their diet is represented by any generalized feed calculations.

StatsCan (2005b: table 23A) has determined 3.452t of "complete grain-based rations" were required to feed 1000 farmed fish in 2001. Of that, 2.495t is in fact not grain based, but consists of minerals, fats, sweeteners, supplements and animal by-products (StatsCan, 2005b: 9), while the remainder is made up of 0.666t wheat and 0.292t soybean meal (StatsCan, 2005b: table 23K). As the proportions of the constituents of the non-grain based diet are unknown, and it is not possible to accurately re-integrate generically described "animal by-products" back into whole animals in any case, this part of the analysis will be incomplete.

Other considerations for this category include:

- Freshwater fish account for less than 5% of consumption in Canada and will be included with marine fish (StatsCan, 2003b).
- The weight of canned fish, mostly salmon and tuna, and that of cured and pickled fish will be considered equivalent to live-weight fish; they account for almost 26% of consumption (StatsCan, 2003b).
- Shellfish represent 18.5% of fish consumption (StatsCan, 2003b) and are ocean farmed in Canada, but since they feed naturally they make no demand on land area (AAFC, 2008c).

StatsCan based feed quantity estimations on average weights for salmon of 8lbs (3.6kg) and trout of 5lbs (2.3kg) (2005b: 8); the higher number will be adopted since, as noted, salmon account for the preponderance of both farmed and consumed fish. Table 3.20 shows the 2001 consumption of all fresh, frozen and canned fish, the average weight of salmon and the number of thousands of farmed fish required to meet those quantities, again in bold type.

Table 3.20: Calculation of required farmed fish.

FISH	FES STARTING MASS (KG)	WEIGHT OF FISH (KG)	NUMBER OF FARMED FISH
Fresh or frozen	90,000,000	3.6	25,000,000
Canned	42,000,000	3.6	11,000,000
Total	130,000,000	3.6	**36,000,000**

3.1.3 Dairy products and eggs

The first post-natal nutrition all mammals receive is milk (Early, 1998: 1), an emulsion of fat globules (lipids collectively called milkfat or butterfat) interspersed with a colloidal suspension of large proteins in an aqueous solution (serum) containing minerals, enzymes, acids, lactose and vitamins (Goff, 2009a). The main source of milk in North America is bovines (Potter & Hotchkiss, 1998: 279) and the Canadian dairy herd is predominantly the Holstein breed at over 90% (AAFC, 2009b). Dairy producers in Canada, like those in other nations with industrialized dairy industries, use common milk collection and pooling systems (Early, 1998: 11). This compensates for any variability in the composition of milk, even among cows of the same breed, owing to *inter alia* age, feed and season (Lane, 1998: 165; Potter & Hotchkiss, 1998: 279-280) and makes possible the determination of averages for lipid and protein content (Potter & Hotchkiss, 1998: 280). Butterfat and proteins are the substrates for most dairy products derived from milk or cream.

Regular beverage milk is marketed according to its fat content and is listed in the FES as fluid whole milk (homogenized), 2% butterfat, 1% butterfat and skim (Appendix 1); homogenized milk has a butterfat content of 3.25% and that of skim milk is not more than 0.5% (Dairy Producers Association of Canada, n.d.). Whole milk is mechanically separated using centrifugal cream separators that act on the density difference between the skim milk and the butterfat (Potter & Hotchkiss, 1998: 291). Two methods exist for manufacturing milk with a particular fat content. The first is to simply separate the skim milk from the fat entirely and later reintroduce the quantity of butterfat required to reach the content desired (Early, 1998: 22); the second is to control the rate of separation so that the output is not skim, but milk with the desired fat content (Potter & Hotchkiss, 1998: 291). Both methods are used in Canada (Goff, 2009b) and in either case it is the serum that accounts for the volume.

Specialty milks listed in the FES include lactose-reduced, sterilized, acidophilus bacterium-enhanced and lactose-free milks and must also be added to the total volume. Cream is listed with beverage milk in the FES and will also be added to it. Neither ice cream nor ice milk are a recommended part of nutrition and are not accounted (Health Canada, 2008a).

Milk separated to make cream containing 30-35% fat forms the basis for butter-making (Potter and Hotchkiss, 1998: 369). Cream is an oil-in-water emulsion; water is said to be the continuous phase, while droplets of fat encased in protective phospholipid coats float as the discontinuous phase. Agitating the emulsion, or churning, breaks the oil droplets and causes them to adhere to one another until they begin to form larger and larger clumps of fat. The liquid must be drained and may be consumed as buttermilk, although buttermilk is more commonly produced through fermentation as yoghurt (Goff, 2009c), see below. The final product is the reversed, water-in-oil emulsion containing at least 80% fat called butter (Potter and Hotchkiss, 1998: 370).

It is reasonable to assume that cream (milkfat) extracted from the production of beverage milk supplies some part of butter production, but some butter manufacturers begin with whole milk and "usually" send the skim for drying into milk powder (Goff, 2009d: ¶11). A complete exposition of the dairy industry to determine such specifics is beyond the scope of this work. It will therefore be assumed that butter is made from milk produced specially for that purpose, although this may lead to an estimation of the dairy herd that is higher than actually required. Potter and Hotchkiss approximate 22.8L of milk for every kilogram of butter (1998: 281, table 13.3). The volume of milk required to manufacture the butter consumed in 2001 is calculated in table 3.21. Almost 1.5 million kilolitres of whole milk was centrifuged to separate enough butterfat for this amount.

Table 3.21: Calculation of milk volume required to supply butter.

FES ITEM	FES STARTING VOLUME (KG)	FES CONVERSION FACTOR (KL/KG)	MILK VOLUME (KL)
Butter	65,700,000	0.023	1,500,000

Yoghurt is milk that has undergone lactic acid fermentation and is likely the oldest example of bioengineered food preservation (Jaros & Rohm, 1998: 156). Most, if not all, of the yoghurt available in Canada is made from cow's milk (Staff, 1998: 124). A review of literature does not indicate that a change in volume occurs after fermentation (Goff, 2009c; Jaros & Rohm, 1998; Potter & Hotchkiss, 1998; Staff, 1998), although Staff notes that fruit concentrate may be added between 15-25% of volume (1998: 143). Yoghurt is listed in the FES in both fresh and frozen forms, but there is no other subdivision for additives like fruit (StatsCan, 2003b); therefore, the volume of fresh and frozen yoghurt will be considered as an equivalent volume of milk and added to its total.

Cheese making uses about 35% of the world's milk production (Banks, 2007: 100). The FES lists: cheddar cheese; grated cheese, including cheddar, mozzarella, parmesan and romano; process cheese, which includes Gruyere, cheese slices and prepared cheese snacks; cottage cheese, including ricotta; and other cheese, which includes some 36 other named cheeses (Appendix 1). As previously mentioned, the protein content of milk is important to dairy manufacturers, especially as the principal substrate for cheese-making (Potter & Hotchkiss, 1998: 300) and the standardization of milk that ensures uniformity of content allows for generalizations in the relationship between inputs and outputs. Cheese is described as what remains "after coagulation and whey separation" of milk, cream, or both (Goff, 2009e). Whey constitutes about 90% of milk volume, as it includes the serum, and contains whey proteins (which may be recovered in the cheese) and minerals. Once considered an environmental threat, mostly due to heightened biological oxygen demand in receiving water bodies, whey products have growing value in some markets (Kelly, 2007: 163). That said, whey products are not explicitly mentioned in the FES (Appendix 1) so any Canadian consumption will be assumed as a by-product of cheese production.

Banks suggests production of 1 kg of cheddar cheese requires about 10L of milk (2007: 102). Both Emmons and colleagues (1990: 1384) and Hill (2009) use the Van Slyke and Price formula to arrive at 9.885kg and 9.945kg cheddar cheese yield per 100kg milk, respectively, while Potter and Hotchkiss (1998: 281) aver 10kg milk generally produces 1 kg of any cheese. Since milk has a density of about 1.03kg/L at 20°C (Goff, 2009a) 100kg milk displaces 97.1L. These numbers are compared in table 3.22.

Table 3.22: Relationship between milk quantity and cheese yield.

AUTHOR	CHEESE (KG)	MILK (L)	CHEESE: MILK (KG/L)
Banks (2007)	1.0	10.0	0.10
Emmons, et.al. (1990)	9.985	97.1	0.10
Potter & Hotchkiss (1998)	9.945	97.1	0.10

Therefore, for all the cheeses except cottage cheese the relationship of 10L milk to produce 1kg cheese will be adopted. For cottage cheese, Potter and Hotchkiss (1998:281) suggest 6.3kg, or 6.5L, milk makes 1kg. The milk required to make the nearly 46,000 tonnes of cheese consumed is calculated in table 3.23.

Table 3.23: Calculation of milk required to supply cheese consumption.

FES ITEM	FES STARTING MASS (KG)	VOLUME OF MILK (L/KG)	REQUIRED VOLUME OF MILK (KL)
Cheese (except cottage cheese)	22,100,000	10	221,000
Cottage cheese	23,900,000	6.5	155,000
Total	46,000,000	n/a	376,000

Condensed and evaporated milk are listed together in the FES (Appendix 1) and Potter and Hotchkiss (1998: 281) suggest 2.3kg and 2.4kg milk, respectively, makes 1kg of each product. The slightly higher value is used here and is converted using the milk density relationship, 1.03kg/L (Goff, 2009a), to 2.5L milk per litre of product. The starting volume of milk evaporated or condensed to provide for those categories in the amounts consumed in 2001 is displayed in table 3.24.

Table 3.24: Calculation of milk required to supply evaporated milk consumption.

FES ITEM	FES STARTING VOLUME (KL)	RELATIONSHIP TO MILK (L:L)	REQUIRED VOLUME OF MILK (KL)
Evaporated and condensed milk	23,800	2.5:1	59,700

Once the milk required to support the 2001 Canadian diet is known, the size of the dairy herd can be found. A "dairy year" runs from August 1 until the following July 31 so a figure must be derived from both the 2000-2001 and 2001-2002 reports. The former says an average Canadian dairy cow produced 9,152kg of milk, while in 2001-2002 the figure was 9,242 (Canadian Dairy Commission [CDC], 2001; CDC, 2002). Taking the median, 9,197kg, and using the same milk density relationship as for cheese, above (Goff, 2009a), the yield is found to be equivalent to 8,929 litres of milk per cow per annum.

The totals from the tables 3.21, 3.23, and 3.24 are added to the FES quantities of liquid milk, milk specialty products, and yoghurt products to provide the total quantity of milk and dairy products consumed in 2001. This is shown, along with the average annual milk production from a single Canadian cow and the number of animals required to produce the total, in bold type, in table 3.25.

Table 3.25: Calculation of total milk and the animals required for its supply.

FES ITEM	FES STARTING VOLUME (KL)	VOLUME FROM TABLES 3.21, 3.23 & 3.24 (KL)	TOTAL CONSUMED VOLUME (KL)	MILK PER COW (KL/YR)	NUMBER OF ANIMALS
Milk	2,340,000	1,940,000	4,280,000	8.929	**479,000**

There is an "other dairy products" category in the FES that contains powdered and chocolate milk, buttermilk, eggnog and other beverage milks and drinkable yoghurt, alongside sour cream and various creamy spreads, such as chip dip, garlic spreads and whip cream (Appendix 1). This presents some difficulty for analysis in that accounting for the milk and yoghurt products is appropriate, but for the cream-based products would constitute double counting and there is no way to disaggregate the two. Given the available data, there does not appear to be an argument that justifies apportioning any fraction to the milk volume, while it is arguable that very little of the list are nutritionally essential foods (Health Canada, 2008a). Therefore these data are not used in the analysis.

Eggs are listed with dairy in the FES, but are largely supplied by chickens. StatsCan found the average number of eggs produced by a chicken in 2001 to be 270 (StatsCan, 2009: survey 003-0020). The number of eggs per chicken will be divided into the total in the FES to give the number of chickens required to support this consumption. The total eggs consumed, the average number of eggs produced by a Canadian chicken in 2001, and the number of chickens fed to supply the eggs, in bold type, are shown in table 3.26.

Table 3.26: Calculation of eggs and the chickens required for their supply.

FES ITEM	FES STARTING QUANTITY	EGGS PER CHICKEN PER YEAR	NUMBER OF ANIMALS
Eggs	3,300,000,000	270	**12,200,000**

3.1.4 Bakery and other cereal products

Cereal goods fall into three broad areas in the FES: baked goods, including bread, rolls and buns, and crackers; pasta products; and rice, breakfast cereals, flours and flour-based mixes. Within these broad groups there are nineteen categories comprising 280 individual foods (Appendix 1). The main constituent of most baked goods and pasta is wheat flour (Potter & Hotchkiss, 1998: 388) and fortunately most recipes for baked goods express ingredients as a percentage of the weight of flour used (Gisslen, 1985: 5), while pasta is generally 12% moisture by weight when finished (Potter & Hotchkiss, 1998: 388) making calculation of grain requirement relatively facile. Rice is not grown in Canada (FAO, 2009) and must be substituted for. There are several categories, like cookies, doughnuts, and other baked goods, that are almost entirely non-essential.

Grinding flour evolved from a simple process for crushing seeds. Each grain has a complicated structure designed to protect the seed until germination and growth conditions are right. A hard, multi-layered outer casing, the bran, protects the nutritious interior, including the starchy endosperm that initially feeds the new plant, and the germ, which carries the genetic material (Potter & Hotchkiss, 1998: 383; 385, figure 17.1). In the earliest innovation after natural stones, original millers pounded the whole grain in a pestle-and-mortar arrangement to make whole grain flour; mechanized flour milling, grinding whole grain between two rotating circular stones, dates back perhaps 7500 years. The process for separating the darker bran from the lighter endosperm to make so-called white flour, called the gradual reduction process, developed over the last three hundred years. The modern mill begins with the break process that passes grain through a series of progressively smaller, fluted cast-iron rollers that crack and flake off the bran and the germ, each pass followed by sieving through progressively smaller screens that separates the endosperm (Catterall & Cauvain, 2007: 333-335). The endosperm fragments, called semolina, are then passed through the reduction system. This series of smooth rollers produces finished flour of different grades, in declining quality from beginning to end (Catterall & Cauvain, 2007: 345) The bran can also be ground and added to produce different types of brown flour (Catterall & Cauvain, 2007: 347), but is mostly destined for animal feed (Canadian Wheat Board, 2008). If the mill is set to make white flour, only the endosperm is used and represents between 76-78% of the mass of wheat, called the extraction rate. Blended brown flours have an extraction rate of approximately 90% and whole wheat 100% (Catterall & Cauvain, 2007: 347). Flours made from rye and other grains, while milled in the same fashion, do not have the proteins (glutens) required for breadmaking and must be blended with wheat flour; for example, light rye bread is made using 60% wheat flour and 40% rye flour (Cauvain, 2007: 372, 375). The extraction rate applied will depend on the item in question; these are explained below.

Bread is a standalone category in the FES with no distinction made between white or whole wheat varieties and no mention of breads made from

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other grasses like rye or those made from lesser-known grains such as spelt, kamut or quinoa (Canadian Grain Commission [CGC], 2009; Appendix 1). However, since breads made from any of these grains will be functionally similar as food and since the 2001 Canadian average yield for both wheat and rye was identical (StatsCan, 2009: survey 001-0010), assuming all rye breads are made from wheat does not change the analysis of land area. Yield data for spelt, kamut and quinoa are not readily available for Canada (FAO, 2009; StatsCan, 2009), although they are all grown commercially here (CGC, 2009); it will be assumed that wheat is an acceptable substitute for these grains in bread.

As mentioned, bread formulae are related to the mass of flour, so if a typical recipe can be established and a reasonable estimate of weight lost to dehydration and processing can be made, the flour used can be calculated from the mass of the finished product. Gisslen (1985: 34) addresses scaling commercial dough recipes, noting that evaporative weight loss is 10-13%, or 50-65g per 500g, and later suggests adding 50g of dough for every 450g finished product, or 11% extra, to account for "baking loss" (1985: 73). Wiggins and Cauvain (2007: 171, figure 5.18), in a more detailed consideration of losses throughout a processing plant, arrive at the same figure, 11%. Some of the loss must be dough adhering to preparation and cooking surfaces and mixing and cutting blades, but most is lost as water is evaporated during baking. Due to numerical agreement 11% total loss is accepted. Perhaps somewhat arbitrarily a loss of 10% will be accounted; this represents an attempt at realism in acknowledging material loss (minus 1% from 11%), while maintaining a conservative estimate by attributing most of the loss to evaporation.

Further assumed is an extraction rate for flour from wheat of 90%, as for brown flour, above, because although it leads to a less conservative estimate than the extraction rate for white flour (~77%), it is realistic. One hundred percent whole wheat flour includes the milled germ, which contains much fat and becomes rancid in storage, so is less used commercially. Also, the milled bran and germ in whole grain flour have other effects that detract from the quality of the bread and so the use of whole wheat flour is usually augmented with other flour (Gisslen, 1985: 13). To allocate all bread using white flour extraction rates would ignore easily available information that a great many bread products for sale in Canada are made from some kind of blended flour (e.g. Canada Bread Company Limited, 2005).

Table 3.27 shows the commercial formulations of white and whole wheat breads if 100 units of flour are used, the application of a 10% loss of water by mass, the change in the percent share of flour, and the factor used to convert the mass of bread consumed to its equivalent grain at a 90% flour extraction rate. The masses of bread, rolls, and the like consumed in Canada in 2001 are multiplied by 0.64, determined in table 3.27, to obtain the amount of wheat required for production (StatsCan, 2003b). Before calculating the wheat required for bread and related products, the quantities from several categories must be transformed to usable units.

Table 3.27: Comparison of contributions (by mass and percent) of ingredients in bread and calculation of conversion factor.

INGREDIENT	WHITE	WHOLE WHEAT
Flour	100g	100g
Water	60g	62g
Yeast	3.75g	3g
Salt	2.5g	2g
Sugar/ malt syrup	3.75g	4g
Non-fat milk solids	5g	3g
Shortening	3.75g	4g
Yield	178.75g	178g
% flour	56	56
% flour (-10% water)	58	57
Conversion for FES (90% extraction; unitless)	0.64	0.64

Source for masses: (Gisslen, 1985: 47; 48).

The FES category "unsweetened rolls and buns" includes scones, tea biscuits, bagels and other buns traditionally eaten for breakfast, Kaisers and other buns used for sandwiches, and dinner rolls and hamburger and hotdog buns (Appendix 1). As these are given as a number of dozen rolls consumed an equivalent mass of finished product must be determined. Rolls and buns begin with as little as 45g of dough for dinner rolls to 60g for Kaisers and 50-55g for bagels (Gisslen, 1985: 50, 66, 68). As the numbers of each item are unknown, the mean is an inappropriate measure as it cannot be realistically weighted. Therefore the median of the range 45-60g, 52.5g per unit (also the median of the range for bagels alone) is chosen and the calculation is shown in table 3.28.

Table 3.28: Calculation of the mass of rolls from initial FES numerical quantity.

FES ITEM	FES STARTING QUANTITY	AVERAGE MASS OF DOUGH PER ROLL (T)	MASS OF ROLLS (T)
Rolls	3,370,000,000	0.0000525	177,000

Buns and rolls are prepared using the same manufacturing processes and the same flour as bread, above, so the same derivations apply for weight loss and flour extraction rate. The recipes are again expressed as a percentage of the flour used and table 3.29 gives those for hard rolls, like Kaisers, soft rolls, like dinner rolls, and bagels.

<u>Table 3.29:</u> Comparison of contributions (by mass and percent) of ingredients in various rolls and calculation of conversion factor.

INGREDIENT	SOFT ROLLS	HARD ROLLS	BAGELS
Flour	100g	100g	100g
Water	57g	55g	50g
Yeast	3.5g	3.5g	3g
Salt	1.75	2.25g	1.5g
Sugar/ malt syrup	9.5	2.25g	6g
Egg whites	-	2.25g	-
Shortening	4.75g	2.25g	(oil) 0.8g
Butter	4.75g	-	-
Yield	186.0g	167.5g	161.0g
% flour	54	60	62
% flour (-10% water)	55	62	64
Conversion for FES (90% extraction; unitless)	0.62	0.69	0.71

Source for masses: (Gisslen, 1985: 44; 48; 50).

The mean of the three conversion factors, 0.67, is adopted to convert the mass of buns consumed to wheat grains needed.

Crackers and crisp breads follow in the FES and include soda crackers (saltines), soup crackers, Melba toast, and crisp breads with brand names like Stoned Wheat Thins™ and Triscuit™ (Appendix 1). Crackers and their ilk are made with dough that is similar to bread, though with slightly less water and with a different cooking process (Manley, 2001: 41). Crisp breads are also similar to regular bread, but are made with much more water, later removed (Manley, 2001: 28; 30). Again as above, formulations are made against 100 units of brown wheat flour extracted as 90% of the mass of whole grain. In the case of these products, however, the final product is dried to 5% moisture (Manley, 2001: 30).

Table 3.30 shows the commercial formulations of crackers and crisp bread if 100 units of flour are used, the application of a 95% loss of water by mass, the change in the percent share of flour and the factor used to convert the mass of product consumed to its equivalent grain at a 90% flour extraction rate.

Table 3.30: Comparison of contributions (by mass and percent) of ingredients in crackers and crisp breads and calculation of conversion factor.

INGREDIENT	CRACKERS	CRISP BREAD
Flour	100g	100g
Water	29.5g	129g
Yeast	0.15g	-
Salt	1.62g	1.15g
Soda	0.89g	-
Non-fat milk solids	3.7g	-
Shortening	11.82g	-
Yield	147.68g	230.15g
% flour	68	43
% flour (-95% water)	84	88
Conversion for FES (90% extraction; unitless)	0.93	0.98

Source: (Manley, 2001: 30; 41).

Both the mean and the median of the conversion factor are 0.955, so this number will be used.

While cookies, sweet biscuits, doughnuts, and other sweet goods are not essential and are not accounted here, the same cannot be said for muffins.

Muffins are made with similar ingredients and in much the same fashion as bread (Gisslen, 1985: 85) and experience the same 10% moisture loss during baking. Table 3.31 shows a typical muffin recipe and the calculation of the conversion factor.

Table 3.31: Ingredients in muffins and calculation of conversion factor.

INGREDIENT	MUFFINS
Flour	100g
Sugar	30g
Baking powder	6g
Salt	1.25g
Eggs	20g
Water	80g
Shortening	30g
Yield	267.25g
% flour	37
% flour (-10% water)	39
Conversion for FES (90% extraction; unitless)	0.44

Source for masses: (Gisslen, 1985: 90).

Muffins are also listed in the FES as number eaten and must be converted to mass before the application of the conversion factor. Gisslen (1985: 90) directs bakers to use approximately 60g of dough per muffin, which will be adopted here.

Pastes of semolina and water formed into sheets and cut into dumplings called noodles have been produced nearly as long as bread, perhaps as long as 6000 years in China. In Europe evidence from ancient art and text indicates the Romans had developed pasta in 600 BCE. Production was artisanal until the Industrial Revolution brought mechanization, extruders and hydraulic presses; the first fully modernized plant, with continuous extrusion and drying producing ready-to-eat pasta, began operating in 1946 (Dexter, 2004: 249-250). In the FES pasta is listed in three groups: canned pasta products; fresh or dry pasta; and dry pasta mixes (Appendix 1). The latter two are mostly dry pasta and canned pasta start with it, so a general discussion of the derivation of the wheat equivalent will be made followed by details specific to the canned product. Both Italian pasta and Asian noodles are described in all three groups; Dexter notes that while the processing steps are quite different the recipes and final moisture contents are similar (2004: 257; 264), so they are accounted for in the same fashion.

Italian pasta is made from semolina, the course particles of the endosperm, rather than ground flour, and preferably obtained from high-quality wheat (Dexter, 2004: 250). Since the bran is removed completely for semolina, the extraction rate for semolina is the same as that for white flour, between 76-78% or 77% (Catterall & Cauvain, 2007: 346), as will be used here. Potter and Hotchkiss (1998: 388) state simply that pasta should be dried to "about 12%", while Dexter (2004: 257) is no more specific in his long overview of the multi-stage, controlled drying process in the modern plant, suggesting "approximately 12.5%." Since a higher moisture value leads arithmetically to lesser quantities of wheat required and is thus a conservative measure, 12.5% moisture will be used. The formula for pasta is 30 units of water for every 100 of semolina. Asian noodles are made not from semolina, but from a variety of flours, mostly wheat flour[6] free of bran, i.e. extracted at a rate of 77% (Dexter, 2004: 259). Table 3.32 shows the calculations determining the conversion of pasta to wheat.

Table 3.32: Comparison of contributions (by mass and percent) of ingredients in pasta.

INGREDIENT	PASTA
Flour	100g
Water	30g
Salt	-
Yield	130g
% flour	77
% flour (-87.5% water)	96
Conversion for FES (unitless)	1.25

Source for masses: (Dexter, 2004: 251).

As can be seen, whole wheat must be produced to account for the milling loss of the bran, resulting in a conversion factor of 1.25.

Canned pasta includes a variety of ready-to-eat noodle types and shapes in a sauce (Appendix 1). Lopez discusses the procedure for canning spaghetti, which will be assumed here to be typical of all canned pasta. As the pasta is cooked prior to canning it is fully hydrated, weighs about 2.5 times its dry mass, and takes up from 33-50% of the volume of the package (Lopez: 1987a: 316-317). Assuming the density of fully hydrated pasta is about 1kg/L, a conservative estimation of the dry weight of pasta from a can is 33% ÷ 2.5 = 13% of the volume given in the FES. As its constituency cannot be determined, the sauce will not be accounted for. Table 3.33 shows the steps in converting litres of canned pasta to the mass equivalent.

[6] Perhaps 30-40% of all wheat flour in Southeast Asia is used for making noodles (Dexter, 2004: 258).

Table 3.33: Calculation of mass of pasta from canned volume.

FES ITEM	FES STARTING QUANTITY (L)	% DRY MASS OF PASTA	MASS OF PASTA (KG)
Canned pasta products	29,900,000	13	3,880,000

The mass of wheat accounted for by pasta consumption, including the result from table 3.33, is determined in table 3.34.

Table 3.34: Total mass of pasta.

FES ITEM	FES STARTING QUANTITY (T)
Canned pasta products	3,880
Dry or fresh pasta	149,000
Pasta mixes	35,800
Total	189,000

In table 3.35 the totals from tables 3.28 and 3.34 are listed with bread, crackers and crisp breads, their respective conversion factors, and the resulting quantities of wheat ascribed to their production; the final quantity of wheat is in bold type.

Table 3.35: Calculation of wheat required for bread, rolls, crackers and pasta.

FES ITEM	QUANTITY FROM FES, TABLES 3.28 & 3.34 (T)	CONVERSION FACTOR (UNITLESS)	MASS OF WHEAT (T)
Bread	573,000	0.64	367,000
Rolls	177,000	0.67	118,000
Crackers and crisp breads	53,500	0.995	53,200
Pasta	189,000	1.25	236,000
Total	n/a	n/a	**774,000**

In the FES rice is found as white, brown, parboiled and prepared types (Appendix 1) and, as mentioned above, is not a commercially grown cereal in Canada (FAO, 2009). A substitution must therefore be made to account for the land area represented by its consumption. Beside rice, cereals also include wheat, rye, barley, oats and corn (GCG, 2009; Potter & Hotchkiss, 1998: 381). As it is reasonable to assume some substitution by grain corn in the event rice is unavailable, accounting for rice consumption is proportional to the fraction of produced amounts for wheat, rye barley, oats and corn using CANSIM II data and calculated in table 3.36 (StatsCan, 2009: survey 001-0010).

Table 3.36: Calculation of production proportions for cereals, 2001.

GRAIN	2001 PRODUCTION (T)	% OF TOTAL
Barley	10,800,000	25.4
Corn (grain)	8,390,000	19.6
Oats	2,690,000	6.3
Rye	228,000	0.5
Wheat	20,600,000	48.2
Total	42,800,000	100

Source: (StatsCan, 2009: survey 001-0010).

The amount of rice consumed, given as mass units in the FES, will be converted to equivalent land areas of each above grain in proportion to the percentages found in table 3.36. While it is beyond the scope of this work to evaluate the nutritional values of foods, a straight substitution in this case is plausible, at least on the grounds of energy equivalency. Equal amounts of rice, whole wheat, and potato flours and corn meal contain between 1000kJ and 1300kJ of energy. A serving of cooked white or brown rice yields about the same energy as a slice of white or whole wheat bread or cooked barley (Health Canada, 2008b: 4-6). Table 3.37 shows the distribution of the 119,000 tonnes of rice consumed in 2001 as if it were Canadian-grown grains. Domestically-produced grain totals are in bold type.

Table 3.37: Calculation for rice as Canadian-grown grain.

GRAIN	% OF TOTAL	RICE AS GRAIN (T)
Total	100	119,000
Barley	25.4	**30,300**
Corn	19.6	**23,400**
Oats	6.3	**7,510**
Rye	0.5	**636**
Wheat	48.2	**57,600**

Flour is listed as a standalone category in the FES, encompassing wheat, rice, rye, oat, corn, buckwheat, and potato flours, amongst others (Appendix 1). The task here is to find a reasonable substitute for such a disparate blend when the proportions of each are unknown. As a comprehensive analysis of the manufacturing techniques and extraction rates for all the flours listed and the subsequent calculation of a single conversion factor is beyond the scope of this work, the 90% extraction rate applied to bread flour, above, will be applied, as will the average yield for all wheat, 1900kg/ha (StatsCan, 2009: survey 001-0010). The weight of all the flour consumed in 2001 is listed in table 3.38, along with the conversion factor derived from the 90% extraction rate of flour from wheat, and the addition to the final mass of wheat, in bold type.

Table 3.38: Calculation of wheat required to supply flour.

FES ITEM	FES STARTING MASS (T)	CONVERSION FACTOR (UNITLESS)	MASS OF WHEAT (T)
Flour	143,000	1.11	**159,000**

"Other cereal grains" is a catch-all category of foods like natural bran, bulgur, wheat germ, couscous, hominy grits, oatmeal and corn meal (Appendix 1), again in undeterminable proportions. As these foods are cereals the proportions found in table 3.36 are applied here. Table 3.39 shows this for the nearly 18 thousand tonnes of other milled and unmilled grains. Domestically-produced grain totals are in bold type.

Table 3.39: Calculation for flour as Canadian-grown grain.

GRAIN	% OF TOTAL	FLOUR AS GRAIN (T)
Total	100	17,900
Barley	25.4	**4,540**
Corn	19.6	**3,510**
Oats	6.3	**1,130**
Rye	0.5	**95**
Wheat	48.2	**8,640**

Breakfast cereals are another unknown mix of grain-based foods found in the FES (Appendix 1). Wheat, rice, corn and oats are the predominant grains and for most cereals only the endosperm are used, either mashed and reformed, or mechanically aerated or "puffed" (Potter & Hotchkiss, 1998: 394-395). Finished breakfast cereals are dried to 3-5% moisture from the original moisture content of the grains of about 11% (Potter & Hotchkiss, 1998: 382, table 17.2; 395) and so a conversion factor must be found by dividing the mean moisture content by the finished content before the 77% extraction rate for endosperm from grain can be applied; the calculation of this is shown in table 3.40.

Table 3.40: Calculation of the average moisture content and conversion factor for breakfast cereals.

GRAIN	MOISTURE CONTENT
Corn	11%
Oats	13%
Wheat	11%
Mean	11.7%
Cereal moisture content	5%
FES conversion factor	2.34

Source: (Potter & Hotchkiss, 1998: 382, table 17.2).

After the converted amount is determined it is apportioned according to table 3.36 as for rice and other cereal grains, above. Breakfast cereals must undergo a two-step process to find the final demand they pose on land area. First, the moisture content is increased to its original proportion using the conversion factor from table 3.40; second, it is apportioned as for rice and other grains, above, based on table 3.36. The results are shown in tables 3.41 and 3.42, respectively, with the masses to be added to the final grains quantities in the latter table in bold type.

Table 3.41: Calculation of grain required for breakfast cereal consumption.

FES ITEM	FES STARTING MASS (T)	FES CONVERSION FACTOR (UNITLESS)	MASS OF GRAINS (T)
Breakfast cereals	143,000	2.34	335,000

Table 3.42: Calculation for breakfast cereals as Canadian-grown grain.

GRAIN	% OF TOTAL	BREAKFAST CEREALS AS GRAIN (T)
Total	100	335,000
Barley	25.4	**85,000**
Corn	19.6	**65,800**
Oats	6.3	**21,100**
Rye	0.5	**1,790**
Wheat	48.2	**162,000**

The remaining cereal products are cake mixes and cereal-based snack foods that are not considered nutritional and are not accounted here (Health Canada, 2008a). The totals from tables 3.35, 3.37, 3.38, 3.39, and 3.42 are collected in table 3.84, where the final areal demand for such land is determined.

3.1.5 Fruit and nuts

Over 170 kinds of fresh, frozen, preserved and juiced fruits from around the world were eaten in Canada in 2001 (Appendix 1). Only five orchard fruits, five berries, both sweet and sour cherries, and melons (in small quantities) are produced commercially in Canada (FAO, 2009; StatsCan, 2009: survey 001-0009). Not only must consumption of domestically-produced fruits be satisfied by 2001 Canadian fruit production, but in order to satisfy this analysis the areas required to provide substitutes for imported species must be as well.

There are several fruits listed in the FES in litres, like strawberries, or as the number consumed rather than as a mass, like grapefruits and melons, and thus require conversion (StatsCan, 2003b). The United States Department of Agriculture's (USDA) Food and Nutrition Service publishes commodity fact sheets for many foods including grapefruit (USDA, 2007: 123). The USDA's National Agricultural Statistics Service (NASS) provides some conversions in annual statistical reports including for strawberries and watermelon (2009: vi, vii). The following table relates the number of grapefruits and litres of strawberries from the FES to equivalent mass according to the above-noted sources.

Table 3.43: Calculation of per unit mass for selected fruits.

FRUIT	UNIT	MASS (KG)	CONVERSION FACTOR
Grapefruit	27-32 large fruit	15.4-17.7	0.56kg/single fruit
Strawberries	Crate (26.4L)	16.3	0.68kg/L

Source: (USDA, 2007; 123; 2009: vi)

Grapefruit are given as a range of weights that for single fruits corresponds to 0.55-0.57kg; both the mean and the median are 0.56kg and this value is used. For strawberries the value is essentially a bulk density measurement, 0.68kg/L.

Melons create an additional complication in that they have myriad harvest weights, dependant on the variety or species. Complimentary here to the USDA data for watermelons (2009: vii), a document has been prepared by Penn State University (n.d.) covering the production and marketing of cantaloupes that lists the harvest weights of 11 cultivars. The range is listed and the mean is calculated, as shown in table 3.44. As there is a significant difference in the values and there is no way to know the distribution of melon types in the FES (StatsCan, 2003b), an average weighted by Canadian production, 64% melons like cantaloupe and 36% watermelon (FAO, 2009) is calculated and also shown in table 3.44.

Table 3.44: Calculation of per unit mass for melons.

FRUIT	CRITERION	MASS (KG)	MASS/MELON (KG)
Cantaloupe	Range (11 varieties)	1.8-3.2	2.5
Watermelon	Single average melon	11.3	11.3
Weighted cantaloupe	64% production area	2.5	- 1.6 -
Weighted watermelon	22% production area	11.3	- 4.1 -
Mean melon weight	100% production area	-	2.9

Source: (FAO, 2009; Penn State, n.d.: 2, table 1; USDA, 2009: vii)

Although the accuracy of this result, 2.9kg, is somewhat questionable, an alternative applicable measure of central tendency, the median, 6.7kg, is equally unsatisfactory in that it is likely too high. Since the lower measure is more conservative, it is adopted. Melons were produced in such small quantities in

2001 Canada that StatsCan does not collect data, although the FAO (2009) has estimated planted area, production and yield. The mass of fruits given in numeric quantities in the FES must be first converted and this is shown in table 3.45.

Table 3.45: Calculation of the mass of fruits from initial FES numerical quantities.

FES ITEM	FES STARTING QUANTITY (# UNLESS NOTED)	CONVERSION FACTOR (T/UNIT)	MASS OF FRUIT (T)
Grapefruits	155,000,000	0.00056	86,900
Melons	102,000,000	0.00290	**294,000**
Strawberries	47,800,000 L	0.00068	**32,500**

After fresh fruit is accounted for, frozen fruits are analyzed in much the same manner. There is a similar mix of domestic and imported fruits, both berries and tree fruits, in an unknown distribution in the FES (Appendix 1) that will be apportioned against table 3.53, below. Although they are 85-90% water, fruits are not dehydrated prior to freezing except for some osmotic dehydration caused by the syrup or powdered sugar used mainly as preservative (De Ancos, Sánchez-Moreno, De Pascual-Teresa & Cano, 2006: 59, 65).

Dried fruit does occur in the FES as a single group comprising raisins and an "other dried fruit/preserves" category (Appendix 1). Drying involves the removal of free and bound water from fruits using either natural or mechanical methods involving warm-air convection, surface conduction, infrared radiation, or (microwave) molecular excitation. Regardless of the method and process the drying effects of fruit are similar and thus may be discussed generally (Barta, 2006: 82-84).

The main variety of grape used for raisin production in North America, primarily in the US, is the Thompson seedless variety and raisin-making is the second most common use for grapes in the world after wine-making (Bhat, Desai & Suleiman, 2006: 439). Grapes have an initial moisture content of around 86% by mass and are dried to 14% moisture by mass (Bhat et al., 2006: 442); this will be arithmetically reversed to find the starting mass. The mass of grapes is obtained by initially multiplying the mass of raisins found in the FES by 0.14 to find a mass of water. This is subtracted from the starting mass to find the mass of solids. The mass of dried solids is increased by a factor of 6.14 (0.86/0.14) to an approximate initial water content of 31,530kg, which is in turn divided into the mass of solids, giving a starting dried solids percentage of grapes, 16.3%. The divisor is increased until the result is 14% (86% moisture). As suggested above, different grapes are eaten fresh, used for making raisins or for beverage purposes. However, no distinction is made for grape variety in this study, so the mass is added to the total for grapes.

The list of dried and preserved fruit includes both domestic and imported items, as well as items like fruit bars that are processed beyond drying and candied fruits and cherries in syrup; since over 80% of the list is simply dried fruit the entire category is analyzed as such (Appendix 1). All fruits begin, as mentioned, with a moisture content of 85-90% (De Ancos et al., 2006: 59) and all are dried to between 12-16% (Pátaki, 2006: 219). The median of both ranges, 87.5% and 14%, respectively, will be applied as for grapes, immediately above, as will the iteration process. The final mass will be apportioned to domestic fruits' land area using table 3.53. The mass of fresh fruit that went into the manufacture of raisins and dried fruit is shown in table 3.46. The amount to be added to the final total for grapes is in bold type. The total for dried fruit is distributed against domestic production in table 3.56, below.

Table 3.46: Mass of fruit as raisins and dried fruits.

FES ITEM	FES STARTING MASS (T)	FES STARTING MOISTURE (%)	FES STARTING DRY MASS (T)	FINAL MOISTURE CONTENT (%)	FINAL MASS OF FRUIT (T)
Raisins	5,970	14.0	5,130	86.0	**36,700**
Dried fruit	11,900	14.0	10,300	87.5	82,200

Fruit juice not from concentrate includes apple, orange and grapefruit juices and also contains an "other" category that lists the juices of 17 distinct domestic and imported fruits. Juices are either clear, like apple juice, or cloudy, like orange juice, but the process for extracting the juice is the same; clear juices additionally undergo filtration during processing (Horváth-Kerkai, 2006: 205).

Commercial extraction of fruit juices in North America is done by the "squeezer-type" and "reamer-type" extractors (Hui, 2004: 367). Unfortunately, Hui (2004: 368) only gives the extraction rate for the squeezer-type, stating the average production capacity is 500L orange juice per tonne oranges, which amounts to 50% extraction by mass. The FAO value is slightly higher at 54% extraction rate for oranges, 75% for grapes, 48% for grapefruits, 33% for lemons and 72% for apples in the US, and 70% for Canadian apples (FAO, n.d.: 195, 272-273). Other literature did not provide more than qualitative statements of extraction rates (Horváth-Kerkai, 2006: 209; Pátaki, 2006: 222; Potter & Hotchkiss, 1998), although Potter and Hotchkiss aver that, equipment differences notwithstanding, all the elements of juice processing are common for all fruits (1998: 432). For the juices specifically named in the FES the respective FAO (n.d.) extraction rates are applied, using the Canadian value for apples, and the result added to domestic production for apples and apportioned against table 3.43 for the others. For the other juice category, the median of the range 54-70%, 62%, will be used and the result apportioned according to table 3.53.

Concentrated fruit juice is mostly orange juice, both as found in the FES and produced globally (Hui, 2006: 376; StatsCan, 2003b), followed by "other concentrated fruit juices." The FAO (n.d.: 272) lists the extraction rate for American orange juice concentrate as 21% and grapefruit juice concentrate at 12%. Orange juice will be assessed at 21% and the other juice category at the median of the above range, 16.5%; both will be apportioned against table 3.53. Using the FAO (n.d.) extraction rates given in above, a conversion factor from litres of juice to tonnes of fruit is derived and applied in table 3.47.

Table 3.47: Calculation of mass of fruit required to make an initial volume of fruit juice.

FES ITEM	FES STARTING QUANTITY (L)	CONVERSION FACTOR (T/L)	MASS OF FRUIT (T)
Apple juice	143,000,000	0.0014	**201,000**
Grapefruit juice	23,900,000	0.0021	50,200
Orange juice	251,000,000	0.0019	476,000
Other juice	388,000,000	0.0016	621,000
Total (excl. apples)	663,000,000	n/a	1,150,000

The mass of fruit required to supply concentrated fruit juice is found is the same manner as in table 3.47 and is displayed in table 3.48. The mass of apples from table 3.47 is added directly to domestic consumption, while the total from the other juices in that table and the total from table 3.48 are distributed against domestic production in table 3.56.

Table 3.48: Calculation of starting mass of fruit from an initial volume of concentrated fruit juice.

FES ITEM	FES STARTING QUANTITY (L)	CONVERSION FACTOR (T/L)	MASS OF FRUIT (T)
Orange juice	41,800,000	0.0048	201,000
Other fruit juice	71,700,000	0.0061	437,000
Total	114,000,000	n/a	638,000

Canned peaches, pineapples, mixed fruit (mostly fruit salads) and fruit cocktails, and "other fruit" are listed in the FES as volume units (StatsCan, 2003b) and so must be converted. The Canadian Agricultural Products Act regulations mandate minimum net and drained weights for five standardized can sizes making estimation of mass equivalence reasonably straight-forward. For peaches and pineapples, for each can size produced[7] the lowest drained weight percentage, i.e. the most conservative estimate, will be adopted. The regulations include fruit salad, which is essentially the mixed fruit category and will thus be used. These figures are found in table 3.49.

Table 3.49: Canned fruits consumed and m/v ratio.

CANNED ITEM	% MASS/VOLUME
Peaches	60[a]
Pineapple	53[b]
Fruits for salad	61[c]

Notes: a) 10fl.oz., sliced, quartered, halves; in water or syrup.
b) 10fl.oz. all styles but crushed; in water.
c) 28fl.oz. in water or syrup.
Source: (DOJC, 2009b).

[7] Not all fruits are sold in every can size.

These ratios will be applied against their respective categories in the FES. For peaches the amount is applied directly against production area. Both pineapples and mixed fruit are apportioned according to table 3.53.

For the remaining category, "other canned fruit," which includes domestic and imported kinds in an unknown distribution, an average for those domestically produced fruit for which there are canning regulations will be determined. All these values and the calculation can be found in table 3.50. The mass of other canned fruit is found by multiplying the volume by 0.54; the result is apportioned according to table 3.53. Conversion factors derived from the regulated minimum drained weights of canned fruit are shown in table 3.51 with the starting volume of the cans and the final mass of fruit. The result for peaches, in bold, is added directly to domestic consumption, while the rest are added to table 3.57.

Table 3.50: Other canned fruits, m/v ratio and mean of the ratio.

CANNED ITEM	% MASS/VOLUME
Blueberries	53[a]
Cherries (sweet)	57[b]
Pears	61[c]
Plums	57[d]
Raspberries	50[e]
Strawberries	43[f]
Average for FES	54

Notes: a) 19fl.oz., in water or syrup.
b) 28fl.oz., not pitted; in syrup or water.
c) 10fl.oz., sliced, quartered, halves; in water or syrup.
d) 28fl.oz., in water or syrup.
e) 14fl.oz., in water or syrup.
f) 14fl.oz., in water or syrup.
Source: (DOJC, 2009b)

Table 3.51: Mass of fruit required to provide the initial canned volume.

FES ITEM	FES STARTING QUANTITY (L)	CONVERSION FACTOR (T/L)	MASS OF FRUIT (T)
Peaches	11,900,000	0.00060	**7,170**
Pineapple	17,900,000	0.00053	9,490
Mixed fruit	29,900,000	0.00061	18,200
Other canned fruit	23,900,000	0.00054	12,900
Total (excl. peaches)	71,700,000	n/a	40,600

The final two fruit categories in the FES, "jams, jellies and other preserves" and "fruit pie fillings," are similar products given in volume units that must be converted to mass (StatsCan, 2003b). Canadian standards for fruit content of jam vary by fruit and according to whether or not pectin, a gelling agent, is added[8]. The range is as little as 27% fruit by mass in jam with pectin added, to 35% in jams with apple or rhubarb and some other fruit, to 45% in pectin-free jams (DOJC, 2009c). Jelly and marmalade are made with juice extracted from fruit, rather than the whole fruit itself, as is jam (Vibhakara & Bawa, 2006: 197-198). As neither the starting quantity of fruit nor the amount of jelly within the category can be accurately determined (StatsCan, 2003b), jelly and marmalade will be treated as jam. Pie fillings contain about 30% fruit by mass (Pátaki, 2006: 226). Since the only products mentioned by name in the FES are low-pectin fruits (StatsCan, 2003b; Vibhakara & Bawa, 2006: 191), since pie fillings contain an amount of fruit similar to that of jam, and since the fruit by mass in pectin-added jam is the most conservative measure, it will be assumed that products in this category contain 27% fruit by mass, apportioned through

[8] Pectin is found naturally in fruits; apples and citrus fruits are examples of fruits high in pectin, while peaches, berries and pineapple are examples with low amounts (Vibhakara & Bawa, 2006: 191).

table 3.53. The results are in table 3.52 and the total is distributed to domestic production in table 3.57.

Table 3.52: Mass of fruit required to manufacture the volume of jam, jelly, other preserves and fruit pie filling.

FES ITEM	FES STARTING QUANTITY (L)	CONVERSION FACTOR (T/L)	MASS OF FRUIT (T)
Jams et.al.	23,800,000	0.00027	6,430
Pie filling	5,970,000	0.00027	1,610
Total	29,800,000	n/a	8,040

Nuts are not commercially produced in Canada (FAO, 2009: StatsCan, 2009) and there are no obvious substitutes short of nutritional comparison, which is beyond the scope of this work.

The mix of domestic fruit that will take the place of imports is proportional to the 2001 tonnes of production for apples, apricots, blueberries, two kinds of cherries, cranberries, grapes, melons, peaches, pears, raspberries, and strawberries (Cowell & Parkinson, 2003: 226; StatsCan, 2009: survey 001-0009). The produced amount for the two types of cherry production is combined. The distribution is shown in table 3.53. Table 3.54 shows the distribution of equivalent masses of various domestic fruit substituting for bananas and citrus fruits, whose FES quantities are shown in the top row. Table 3.55 shows the distribution of equivalent masses of various domestic fruit substituting for other fresh fruit, other tropical fruit and frozen fruit, again with the FES quantities in the top row (Cowell & Parkinson, 2003: 226).

Table 3.53: Calculation of production proportions for fruit, 2001.

FRUIT	2001 PRODUCTION (T)	% OF TOTAL AREA
Apples	488,000	63.0
Apricots	1,370	0.2
Blueberries	67,700	8.6
Cherries	11,100	1.4
Cranberries	34,800	4.5
Grapes	67,200	8.7
Melons	12,400	1.6
Peaches	30,500	3.9
Pears	17,500	2.3
Plums	3,630	0.5
Raspberries	14,600	1.9
Strawberries	26,200	3.4
Total	775,000	100

Source: (FAO, 2009; StatsCan, 2009: survey 001-0009).

Table 3.54: Masses of domestic fruits substituting for bananas and citrus fruit.

FRUIT	%	BANANAS (T)	GRAPEFRUIT (T)	ORANGES (T)	LEMONS & LIMES (T)
FES totals	100	358,000	86,900	233,000	17,900
Apples	63.0	**226,000**	**54,800**	**147,000**	**11,300**
Apricots	0.2	**633**	**154**	**411**	**32**
Blueberries	8.6	**31,300**	**7,590**	**20,300**	**1,560**
Cherries	1.4	**5,120**	**1,240**	**3,330**	**256**
Cranberries	4.5	**16,100**	**3,900**	**10,400**	**803**
Grapes	8.7	**31,100**	**7,540**	**20,200**	**1,550**
Melons	1.6	**5,740**	**1,390**	**3,730**	**287**
Peaches	3.9	**14,100**	**3,430**	**9,170**	**706**
Pears	2.3	**8,070**	**1,960**	**5,240**	**403**
Plums	0.5	**1,680**	**407**	**1,090**	**84**
Raspberries	1.9	**6,740**	**1,640**	**4,380**	**337**
Strawberries	3.4	**12,100**	**2,940**	**7,870**	**605**

Table 3.55: Masses of domestic fruits substituting for other fresh fruit, other tropical fruit and frozen fruit.

FRUIT	%	OTHER FRESH FRUIT (T)	OTHER TROPICAL FRUIT (T)	FROZEN FRUIT (T)
FES totals	100	41,800	77,600	5,970
Apples	63.0	**26,300**	**48,900**	**3,760**
Apricots	0.2	**74**	**137**	**11**
Blueberries	8.6	**3,650**	**6,770**	**521**
Cherries	1.4	**598**	**1,110**	**85**
Cranberries	4.5	**1,880**	**3,480**	**268**
Grapes	8.7	**3,620**	**6,730**	**518**
Melons	1.6	**669**	**1,240**	**96**
Peaches	3.9	**1,650**	**3,060**	**235**
Pears	2.3	**941**	**1,750**	**134**
Plums	0.5	**196**	**364**	**28**
Raspberries	1.9	**786**	**1,460**	**112**
Strawberries	3.4	**1,410**	**2,620**	**202**

Table 3.56 displays the distribution of equivalent masses of various domestic fruit substituting for the amounts of other dried fruit, fruit juices and fruit juices from concentrate, their consumption values shown in the top row. Table 3.57 shows the distribution of equivalent masses of various domestic fruit substituting for other canned fruit and jams, jellies and preserve, with the amounts from the above tables shown in the top row (Cowell & Parkinson, 2003: 226). The mass totals in bold type from tables 3.45, 3.46, 3.47, 3.51, 3.54, 3.55, 3.56, and 3.57 are carried forward to table 3.85.

Table 3.56: Masses of domestic fruits substituting for other dried fruit, other fruit juice and concentrated fruit juice.

FRUIT	%	OTHER DRIED FRUIT (T)	OTHER FRUIT JUICE (T)	CONC. JUICE (T)
FES totals	100	82,200	1,150,000	638,000
Apples	63.0	**51,747**	**723,000**	**402,000**
Apricots	0.2	**145**	**2,030**	**1,130**
Blueberries	8.6	**7,168**	**100,000**	**55,600**
Cherries	1.4	**1,175**	**16,400**	**9,120**
Cranberries	4.5	**3,685**	**51,500**	**28,600**
Grapes	8.7	**7,123**	**99,500**	**55,300**
Melons	1.6	**1,316**	**18,400**	**10,200**
Peaches	3.9	**3,236**	**45,200**	**25,100**
Pears	2.3	**1,849**	**25,800**	**14,400**
Plums	0.5	**385**	**5,380**	**2,990**
Raspberries	1.9	**1,545**	**21,600**	**12,000**
Strawberries	3.4	**2,775**	**38,800**	**21,500**

Table 3.57: Masses of domestic fruits substituting for other canned fruit and jams, jellies and preserves.

FRUIT	%	OTHER CANNED FRUIT (T)	JAMS, JELLIES AND PRESERVES (T)
FES totals	100	40,600	8,060
Apples	63.0	**25,600**	**5,080**
Apricots	0.2	**72**	**14**
Blueberries	8.6	**3,540**	**703**
Cherries	1.4	**581**	**115**
Cranberries	4.5	**1,820**	**362**
Grapes	8.7	**3,520**	**699**
Melons	1.6	**650**	**129**
Peaches	3.9	**1,600**	**318**
Pears	2.3	**914**	**181**
Plums	0.5	**190**	**38**
Raspberries	1.9	**764**	**152**
Strawberries	3.4	**1,370**	**272**

3.1.6 Vegetables

Canadians enjoy about 200 different fresh, frozen, dried and canned vegetables (Appendix 1). CANSIM II and AAFC provides data for 22 vegetables under cultivation in Canada in 2001 that closely match those consumed, as listed in the FES, although in the catch-all, "other" categories there are items not grown here that will be accounted for in much the same manner as imported fruit (AAFC, 2009c; StatsCan, 2003b; StatsCan, 2009: survey 001-0013). Also like fruit, domestic consumption is accounted for and a representation of imported vegetables made from the FES (Cowell & Parkinson, 2003: 226).

There are several field vegetables listed in the FES as a number consumed, rather than as mass, thus requiring conversion. StatsCan publishes the conversion factors it uses for corn, cucumbers and lettuce in annual reports (StatsCan, 2002: 10). The USDA's NASS also publishes conversion factors for cauliflower and celery, as for fruit, above (USDA, 2009: v). The following table relates those vegetables listed numerically in the FES to equivalent mass according to StatsCan and the NASS.

Table 3.58: Calculation of per unit mass for selected fresh vegetables.

VEGETABLE	UNIT	MASS (KG)	MASS/SINGLE VEGETABLE (KG)
Cauliflower	Crate (24 heads)	22.7	0.95
Celery	Crate (3-4 dozen); median 42	27.2	0.65
Corn	Dozen	2.7	0.23
Cucumber	Dozen	5.9	0.49
Lettuce	Dozen	6.8	0.57

Source: (StatsCan, 2002: 10; USDA, 2009: v)

There is a range given for celery in table 3.58 of 3-4 dozen plants per crate; the median is chosen for this calculation. Lettuce is listed in the FES as iceberg lettuce, or head lettuce as in table 3.58, as well as varieties including romaine, leaf and Boston lettuce. As there is no way to disaggregate the types from the FES quantities (Appendix 1), the value given in the table is used. The conversion factors derived in table 3.58 are applied to the FES quantities (StatsCan, 2003b) in table 3.59 and the resulting mass of each, shown in bold type, is added to domestic consumption in table 3.86.

Table 3.59: Calculation of the mass of vegetables from initial FES numerical quantities.

FES ITEM	FES STARTING QUANTITY (#)	CONVERSION FACTOR (UNIT/T)	MASS OF VEGETABLE (T)
Cauliflower	47,800,000	0.00095	**45,400**
Celery	95,500,000	0.00065	**62,100**
Corn	209,000,000	0.00023	**48,100**
Cucumber	197,000,000	0.00049	**96,600**
Lettuce	269,000,000	0.00057	**153,000**

Most of the vegetables listed in the FES are domestically produced and are accounted for directly, but some require additional or special treatment. The first category is "other leaf and stalk vegetables" and includes such things as asparagus, chard, alfalfa sprouts, Asian vegetables, and fresh herbs. Next is "other seed and gourd vegetables" and this list includes lima beans, okra, squash, zucchini, and Asian vegetables. Finally, "other root vegetables" comprises such things as sweet potatoes, water chestnuts, parsnips, horseradish, ginger and garlic (Appendix 1). These will be apportioned directly against table 3.66.

Frozen vegetables include corn, peas, potato products and a catch-all category called "other frozen vegetables" (Appendix 1). The FAO (n.d.: 193-195) states Canadian frozen potatoes lose 40% of their fresh weight, corn only 10%, and generic frozen vegetables 10%; these figures will be used, the last value serving for both peas and other vegetables. The weights of the first three are added to the totals for those vegetables. The results for "other vegetables" are apportioned according to the distribution in table 3.66. The initial mass of fresh vegetables that supplied the consumption of frozen vegetables in 2001 is shown in table 3.60. The bolded values are added directly to domestic consumption in table 3.85, while the total for other frozen vegetables is re-distributed in table 3.68.

Table 3.60: Mass of vegetables required for frozen vegetables.

FES ITEM	FES STARTING QUANTITY (KG)	FAO CONVERSION FACTOR (T/KG)	MASS OF VEGETABLE (T)
Corn	11,900,000	0.0011	**13,100**
Peas	17,900,000	0.0011	**19,700**
Potatoes	89,600,000	0.0017	**152,000**
Other veg.	41,800,000	0.0011	46,000

There are both dried potatoes and "other dried vegetables" in the FES; the latter includes mostly beans and yam, lotus root, onions, garlic and mushrooms in unknown proportions (Appendix 1). The FAO (n.d.: 272) states the dried mass of vegetables is 15% of fresh mass, although offers nothing for potatoes specifically. The same conversion factor will be applied to both categories, with the mass of potatoes applied directly to the total for potatoes and the other vegetables apportioned according to table 3.66. After conversion in table 3.61, the mass of fresh potatoes is added to domestic consumption, while the initial mass of other dried vegetables is re-distributed in table 3.68.

Table 3.61: Mass of vegetables from dried potatoes and other dried vegetables.

FES ITEM	FES STARTING QUANTITY (KG)	FAO CONVERSION FACTOR (T/KG)	MASS OF VEGETABLE (T)
Potatoes – dried	5,970,000	0.0067	**40,000**
Other veg. - dried	11,900,000	0.0067	80,000

Canned vegetables, tomato juice and other vegetable juice are found in the vegetable section of the FES as volume units, i.e. litres, consumed (StatsCan, 2003b) and so must be converted. Canned products must be made with fresh vegetables (Lopez, 1987b: 103) so the yearly consumption conceptually represents a constant demand on the land, even if products may be stored for some time after canning.

Canadian agricultural product regulations mandate minimum net and drained weights for five standardized can sizes making estimation of the mass equivalent reasonably straight-forward. For each item, for each can size produced[9] the lowest drained weight percentage, i.e. the most conservative estimate, will be adopted, except in the following cases or with the following assumptions. Baked beans uses the lowest net weight, rather than drained weight. Canned corn will be assumed to be kernels, rather than creamed. Drained canned tomatoes are assumed to be Canada Fancy grade 65% solids (the highest grade) (DOJC, 2009b).

[9] Not all vegetables are sold in every can size.

Some 20 vegetables are listed as "other canned vegetables" in the FES, but not all are described in the regulation; the average drained weights (i.e. except baked beans) of those that are regulated will be used. The result will be apportioned against table 3.66 (DOJC, 2009b; StatsCan, 2003b). The FAO (n.d.: 272) says US extraction of tomato juice occurs at a rate of 65% and vegetable juice generally at 60%; the latter will be used for "other juice." In Canada tomato juice is extracted at 90% efficiency (FAO, n.d.: 194) and although this is not the most conservative choice, it is the most realistic and will be adopted. Table 3.62 lists the consumption items from the FES (StatsCan, 2003b) and the percent mass per unit volume, both in ounces, from the regulation.

Table 3.62: Canned vegetables consumed and mass/volume ratio.

CANNED ITEM	% MASS/VOLUME
Green or wax beans	54[a]
Baked beans	102[b]
Other beans	60[c]
Corn	64[d]
Mushrooms	52[e]
Peas	61[f]
Tomatoes	66[g]
Other canned veg.	60[h]
Tomato juice	90
Other veg. juice	60

Notes: a) 14fl.oz., short cut.
b) 28fl.oz., vegetarian beans (*cf* pork and beans).
c) 28fl.oz., lima beans
d) 28fl.oz., whole kernel in brine.
e) 28fl.oz., stems and pieces.
f) 28fl.oz., peas.
g) 28fl.oz., Canada Fancy Grade, 65% drained solids.
h) Mean of values a, c, d, e, f, and g, above.

Source: (DOJC, 2009b; Matthews, Phillips & Augustine, 1980: 297, table 4)

In table 3.63 canned vegetables are transformed from a volume measure to equivalent mass with canned, domestically-produced vegetables added directly to table 3.85 and other canned vegetables apportioned against table 3.68.

Table 3.63: Mass of vegetables required to provide the initial canned volume.

FES ITEM	FES STARTING QUANTITY (L)	CONVERSION FACTOR (T/L)	MASS OF VEGETABLE (T)
Green or wax beans	17,900,000	0.00054	**9,670**
Baked beans	23,900,000	0.00102	**24,400**
Other beans	23,900,000	0.00060	**14,300**
Corn	35,800,000	0.00064	**22,900**
Mushrooms	17,900,000	0.00052	**9,320**
Peas	17,900,000	0.00061	**10,900**
Tomatoes	89,600,000	0.00066	**59,100**
Other canned veg.	23,900,000	0.00060	14,300

After determining the mass of fresh vegetables processed into juice in table 3.64, the value for tomatoes is added to the total consumed in table 3.85 and other vegetable juice is re-distributed in table 3.69.

Table 3.64: Calculation of mass of vegetables required to make an initial volume of juice.

FES ITEM	FES STARTING QUANTITY (L)	CONVERSION FACTOR (T/L)	MASS OF VEGETABLE (T)
Tomato juice	41,800,000	0.0011	**46,000**
Other veg. juice	65,700,000	0.0017	112,000

In the FES pickles include eggs, pimentos, walnuts, onions, olives, beets and different cucumber varieties (Appendix 1). The FAO (n.d.: 195) gives a 90% extraction rate for "vegetables prepared by vinegar" that will be used for this category, while other literature is silent on the matter (Nip, 2004: 53; 76, table 3.52: Potter & Hotchkiss, 1998: 271-274). The above-noted mix of pickled items presents a problem with respect to allocation, as it includes eggs and nuts with vegetables. As the solutions are limited without knowing the fraction of each constituent, the results of this conversion will simply be apportioned against table 3.66. The transformation of pickles to a final mass is displayed in table 3.65 and the total is re-distributed in table 3.69.

Table 3.65: Calculation of starting mass of vegetables from an initial volume of pickles.

FES ITEM	FES STARTING QUANTITY (L)	CONVERSION FACTOR (T/L)	MASS OF VEGETABLE (T)
Pickles	51,400,000	0.0011	56,500

The proportions of domestic vegetables that will replace imports are proportional to the 2001 mix of the produced quantities of asparagus, beans-green and wax, beans-dry, broccoli, cabbage, carrots, cauliflower, corn (sweet), cucumbers, lettuce, onions, peas, potatoes, and tomatoes (Cowell & Parkinson, 2003: 226; StatsCan, 2009: survey 001-0013). The distribution is shown in table 3.66. Like fruit, imported vegetables and juiced, canned, frozen, pickled and dried vegetables converted in the tables above are apportioned against the distribution table, 3.66. This begins in table 3.67, which apportions the FES quantities of various "other" categories, found in the top row, to equivalent domestic consumption. These values are later compiled in table 3.85. Table 3.68 collects the totals from the tables above for other canned, other frozen and other dried vegetables and considers them as domestic consumption. The numbers in bold are then carried to table 3.85.

Table 3.66: Calculation of production proportions for vegetables, 2001.

VEGETABLE	2001 PRODUCTION (T)	% OF TOTAL AREA
Asparagus	3,040	0.1
Beans (dry)	300,000	4.5
Beans (green)	47,800	0.7
Beets	20,700	0.3
Broccoli	65,900	1.0
Cabbage	142,000	2.1
Carrots	332,000	5.0
Cauliflower	46,300	0.7
Celery	35,800	0.5
Corn	306,000	4.6
Cucumbers	75,500	1.1
Lettuce	87,700	1.3
Mushrooms	86,400	1.3
Onions	192,000	2.9
Parsnips	4,070	0.1
Peas	74,200	1.1
Peppers	30,700	0.5
Potatoes	4,220,000	63.6
Radishes	6,790	0.1
Spinach	4,170	0.1
Tomatoes	499,000	7.6
Turnips	52,800	0.8
Total	6,630,000	100

Source: (AAFC, 2009c; StatsCan, 2009: survey 001-0013).

Table 3.67: Masses of domestic vegetables substituting for other leaf and stalk vegetables, other seed and gourd vegetables, and other root vegetables.

VEGETABLE	2001 PLANTED AREA (%)	OTHER LEAF & STALK VEG. (T)	OTHER SEED & GOURD VEG. (T)	OTHER ROOT VEG. (T)
FES totals	100	65,700	47,800	35,800
Asparagus	0.1	**30**	**22**	**16**
Beans (dry)	4.5	**2,970**	**2,160**	**1,620**
Beans (green)	0.7	**473**	**344**	**258**
Beets	0.3	**205**	**149**	**112**
Broccoli	1.0	**653**	**475**	**356**
Cabbage	2.1	**1,400**	**1,020**	**765**
Carrots	5.0	**3,280**	**2,390**	**1,790**
Cauliflower	0.7	**458**	**333**	**250**
Celery	0.5	**354**	**258**	**193**
Corn	4.6	**3,030**	**2,210**	**1,650**
Cucumbers	1.1	**748**	**544**	**408**
Lettuce	1.3	**869**	**632**	**474**
Mushrooms	1.3	**855**	**622**	**467**
Onions	2.9	**1,900**	**1,380**	**1,040**
Parsnips	0.1	**40**	**29**	**22**
Peas	1.1	**735**	**534**	**401**
Peppers	0.5	**304**	**221**	**166**
Potatoes	63.6	**41,800**	**30,400**	**22,800**
Radishes	0.1	**67**	**49**	**37**
Spinach	0.1	**41**	**30**	**23**
Tomatoes	7.6	**4,940**	**3,590**	**2,690**
Turnips	0.8	**523**	**380**	**285**

Table 3.68: Masses of domestic vegetables substituting for other canned vegetables, other frozen vegetables, and other dried vegetables.

VEGETABLE	2001 PLANTED AREA (%)	OTHER CANNED VEG. (T)	OTHER FROZEN VEG. (T)	OTHER DRIED VEG. (T)
FES totals	100	14,300	46,000	80,000
Asparagus	0.1	**7**	**21**	**37**
Beans (dry)	4.5	**648**	**2,080**	**3,620**
Beans (green)	0.7	**103**	**331**	**576**
Beets	0.3	**45**	**144**	**250**
Broccoli	1.0	**142**	**457**	**796**
Cabbage	2.1	**306**	**981**	**1,710**
Carrots	5.0	**716**	**2,300**	**4,000**
Cauliflower	0.7	**100**	**321**	**558**
Celery	0.5	**77**	**248**	**432**
Corn	4.6	**662**	**2,120**	**3,700**
Cucumbers	1.1	**163**	**523**	**911**
Lettuce	1.3	**190**	**608**	**1,060**
Mushrooms	1.3	**187**	**599**	**1,040**
Onions	2.9	**414**	**1,330**	**2,310**
Parsnips	0.1	**9**	**28**	**49**
Peas	1.1	**160**	**514**	**895**
Peppers	0.5	**66**	**213**	**371**
Potatoes	63.6	**9,120**	**29,300**	**50,900**
Radishes	0.1	**15**	**47**	**82**
Spinach	0.1	**9**	**29**	**50**
Tomatoes	7.6	**1,080**	**3,460**	**6,020**
Turnips	0.8	**114**	**366**	**637**

Finally, other vegetable juice and pickles and apportioned against domestic consumption in table 3.69, with the equivalent values added to total vegetable consumption in table 3.85.

Table 3.69: Masses of domestic vegetables substituting for other vegetable juice and pickles.

VEGETABLE	2001 PLANTED AREA (%)	OTHER VEG. JUICE (T)	PICKLES. (T)
Total	100	112,000	56,500
Asparagus	0.1	**51**	**26**
Beans (dry)	4.5	**5,050**	**2,560**
Beans (green)	0.7	**804**	**407**
Beets	0.3	**349**	**177**
Broccoli	1.0	**1,110**	**562**
Cabbage	2.1	**2,380**	**1,210**
Carrots	5.0	**5,580**	**2,830**
Cauliflower	0.7	**779**	**394**
Celery	0.5	**603**	**305**
Corn	4.6	**5,160**	**2,610**
Cucumbers	1.1	**1,270**	**643**
Lettuce	1.3	**1,480**	**748**
Mushrooms	1.3	**1,450**	**736**
Onions	2.9	**3,230**	**1,630**
Parsnips	0.1	**68**	**35**
Peas	1.1	**1,250**	**632**
Peppers	0.5	**517**	**262**
Potatoes	63.6	**71,100**	**36,000**
Radishes	0.1	**114**	**58**
Spinach	0.1	**70**	**36**
Tomatoes	7.6	**8,400**	**4,250**
Turnips	0.8	**889**	**450**

3.1.7 Margarine, fats, and oils

The final FES category to be considered comprises lard, margarine, shortening, and cooking/salad oil (Appendix 1). Lard is "meat scraps" heated in vats of water until the fat melts and floats to the surface in a process called rendering (Potter & Hotchkiss, 1998: 365). In Canada, Federal regulations state lard must be rendered from hogs (DOJC, 2009c). The FAO (n.d.: 196) states Canadian slaughter hog yield just over 6kg fat per head, or 130,000 tonnes in 2001 (StatsCan, 2009: survey 003-0028). Lard represented less than 3% of fat consumed as an agri-food product in Canada in 2001 (StatsCan, 2003b), which was easily produced through the above-noted yield of hogs; thus the data will not be included to avoid potential double-counting.

Fats and oils are derived from plants and terrestrial and marine animals. The choice for any given use may depend on an imparted flavour, perceived health benefit, or possessed functional characteristic, but in the globalized market is more likely dependant on cost and availability. Most fats and oils can be substituted for one another (Potter & Hotchkiss, 1998: 361, 363), so the method of comparison is straight-forward.

Margarine and shortening are somewhat functionally interchangeable, which is not surprising since they are manufactured in much the same way (Potter & Hotchkiss, 1998: 372, 374). Since shortening, like lard, only represents about 3% of fats consumed it will be combined with margarine for this analysis. Margarine is made from vegetable oil that has been hydrogenated to raise its melting point above room temperature and is then used as the basis for a water-in-oil emulsion not unlike butter, as described above on page 72 (Potter & Hotchkiss, 1998: 371, 373). Margarine (and shortening) will be converted to an equivalent volume of oil, which will, in turn, be apportioned against the sources of its production.

The density of Canadian-produced oils must be found to convert the mass of margarine into a volume measure that can be applied against the average extraction rate. Table 3.70 shows the density ranges and their medians for corn, soybean, and sunflower oils acceptable in Canada (DOJC, 2009c). The value for corn and sunflower, 0.921kg/L, is representative of the densities found in this table and is selected.

Table 3.70: Calculation of oil density.

ITEM	DENSITY (KG/L)	MEDIAN (KG/L)
Corn	0.917-0.925	0.921
Soybean	0.919-0.925	0.922
Sunflower	0.918-0.923	0.921

Source: (DOJC, 2009c)

Table 3.71 shows the extraction rates for Canadian-grown oil crops and the weighted mean of the rate (FAO, n.d. 193, 194), which will be used for both margarine and for the FES cooking/salad oil category.

Table 3.71: Calculation of extraction rate for vegetable oil.

OILSEED	2001 PRODUCTION (%)	EXTRACTION RATE (%)	WEIGHTED RATE (%)
Canola	33	41	13.5
Corn (grain)	55	45	24.8
Soybean	11	17	1.9
Sunflower	1	41	0
Total	100	n/a	40.2

Source: (FAO, n.d.: 193, 194; StatsCan, 2009: survey 001-0010)

The regulated minimum oil content, 80%, multiplied by the density from table 3.70, 0.921kg/L, provides the conversion factor in table 3.72.

Table 3.72: Volume of oil from initial mass of margarine and shortening.

FES ITEM	FES STARTING QUANTITY (KG)	CONVERSION FACTOR (L/KG)	VOLUME OF VEGETABLE OIL (L)
Margarine	102,000,000	0.736	59,800,000
Shortening	5,970,000	0.736	3,520,000
Total fats as oils	108,000,000	0.736	63,300,000

The total volume of oil from table 3.72 is added with the consumed volume of salad/cooking oil from the FES (StatsCan, 2003b) and the inverse of the weighted extraction rate from table 3.71 is applied. This is shown in table 3.73.

Table 3.73: Calculation of masses of oilseeds from oil volumes.

FES ITEM	FES STARTING QUANTITY (L)	CONVERSION FACTOR (T/L)	MASS OF OILSEEDS (T)
Total fats as oils (table 3.72),	63,300,000	0.0025	158,000
Salad or cooking oils	77,600,000	0.0025	194,000
Total	141,000,000	0.0025	352,000

The mass of oil-bearing seeds from table 3.73 is apportioned against the quantities of Canadian-produced oilseeds in proportions shown in the following table.

Table 3.74: Calculation of production proportions for oilseeds, 2001.

ITEM	2001 PRODUCTION (T)	% OF TOTAL PRODUCED
Canola	5,020,000	33
Corn	8,390,000	55
Soybean	1,640,000	11
Sunflower	104,000	1
Total	15,100,000	100

Source: (StatsCan, 2009: survey 001-0010)

The fractions of domestically-produced canola, corn, soybean, and sunflower from table 3.74 are applied against the total amount of oil consumed from table 3.73 and shown in table 3.75. The totals, displayed in bold, are added directly to total consumption in table 3.83 to find the cropping area.

Table 3.75: Masses of domestic oil crops used in the manufacture cooking/salad oil and margarine.

OIL CROP	% OF TOTAL	OILSEEDS (T)
Total (table 3.73)	100	352,000
Canola	33	**117,000**
Corn	55	**195,000**
Soybean	11	**38,000**
Sunflower	1	**2,410**

3.1.8 Area for animal feed requirements

The 2001 feed requirements for animals, poultry and fish were estimated by StatsCan based on information from the actual 1999 feed used, Provincial livestock experts, feed producers, marketing boards, and the Animal Nutrition Association of Canada (StatsCan, 2005b: 73, table 23K). These coefficients were reported as tonnes per year for wheat, oats, barley, corn, dry peas, soy and canola meal, pasture, dry hay, and silage. Listed without further explanation are "other small grains," which will be interpreted as the "mixed grains" category from the CANSIM II database (StatsCan, 2009: survey 001-0010) and "other roughages," which will be added to hay. Mill screen is also part of the diet, but is accounted for as the by-product of flour production.

Consideration must be made that the production of veal may require the feeding of an additional, maternal parent.[10] Cows and bulls are put together in the spring or early summer; if a cow becomes pregnant, it is fed over the winter until the calf is born early in the next year. If it does not, the cow will be sold for

[10] As a bull services many females, its contribution to each calf is minimal (Cowell & Parkinson, 2003: 234, footnote 4).

slaughter (Canadian Cattlemen's Association, n.d.). It is therefore assumed that for every calf, an additional heifer was fed for one year. However, as mentioned previously, dairy cattle are impregnated to ensure lactation (Ontario Veal Association, 2003); therefore, the number of calves slaughtered for veal plus the number of replacement dairy calves is compared against the dairy cows required. If the number of calves is less, it will be assumed all the 2001 Canadian consumption was met from this source; this is realistic since users of a sustainable system will make use of all available materials before producing new materials. If the number of calves exceeds the number of dairy cows, area for feeding beef heifers equal to the difference will added. Some 1.07 million dairy heifers were on farms in Canada in 2001, while replacement calves numbered nearly 520,000 and the number slaughtered for consumption was calculated in table 3.6 is about 101,000 (StatsCan, 2009: survey 003-0032. Therefore, veal consumption is met by the dairy herd in excess of the required replacements.

The numbers of animals fed to support Canadians in 2001 found in sections 3.1.1, 3.1.2, and 3.1.3 are compiled in the following series of tables. Table 3.76 displays barley, corn, and wheat in tonnes. The totals in bold type are added directly to domestic consumption, but the others must undergo further transformation. Oats and mixed grains are not fed to pigs, chickens, turkeys, or fish and are omitted from table 3.77, which shows the quantities that supported the other animals. Table 3.78 shows tonnes of legumes and canola, which was fed to all animals.

Table 3.76: Barley, corn, and wheat grown to support 2001 Canadian meat, dairy and fish consumption.

ANIMAL	NUMBER FED	BARLEY (T)	CORN (T)	WHEAT (T)
Beef cattle	2,240,000	2,150,000	382,000	78,200
Calves	101,000	8,180	48,200	1,110
Dairy cattle	479,000	358,000	24,900	436,000
Sheep	620,000	16,100	3,100	620
Swine	7,860,000	574,000	944,000	220,000
Chickens (layers)	12,200,000	0	125,000	138,000
Chickens (broilers)	305,000,000	91,600	428,000	214,000
Turkeys	9,720,000	0	68,100	51,500
Aquaculture	36,000,000	0	0	21,600
Total	n/a	**3,200,000**	**2,020,000**	**1,160,000**

Table 3.77: Mixed grain and oats grown to support 2001 Canadian meat, dairy and fish consumption.

ANIMAL	NUMBER FED	MIXED GRAIN (T)	OATS (T)
Beef cattle	2,240,000	53,700	841,000
Calves	101,000	101	8,380
Dairy cattle	479,000	24,900	9,570
Sheep	620,000	620	3,720
Swine	7,860,000	0	0
Total	n/a	**79,300**	**862,000**

Table 3.78: Legumes and canola grown to support 2001 Canadian meat, dairy and fish consumption.

ANIMAL	NUMBER FED	CANOLA MEAL (T)	PEAS (T)	SOYBEAN MEAL (T)
Beef cattle	2,240,000	58,100	51,400	130,000
Calves	101,000	2,520	606	5,450
Dairy cattle	479,000	45,500	1,440	127,000
Sheep	620,000	620	620	1,240
Swine	7,860,000	94,400	55,000	252,000
Chickens – layers	12,200,000	25,600	0	41,500
Chickens – broilers	305,000,000	30,500	0	153,000
Turkeys	9,720,000	5,830	0	36,000
Aquaculture	36,000,000	0	0	8,790
Total	n/a	263,000	**109,000**	754,000

Peas are added directly to their consumption total for vegetables, but soybean and canola meals must be further converted to their equivalent whole masses, which are then added to domestic consumption in table 3.83. The inverse of the soybean meal extraction rate of 76% and the canola rate of 61% provide the final values (FAO, n.d.: 194), as shown in table 3.79.

Table 3.79: Calculation of mass of canola and soybeans required to supply animal feed meal.

MEAL TYPE	QUANTITY FROM TABLE 3.78 (T)	CONVERSION FACTOR (UNITLESS)	MASS OF SEEDS OR BEANS (T)
Canola meal	263,000	1.64	**432,000**
Soybean meal	754,000	1.32	**996,000**

The production of soybean and canola meal is also a by-product of food oil extraction or *vice versa*. Since the amounts of these crops required for animal feed exceed those required for the extraction of food oil, the oil for human use is dropped from the calculation to avoid double-counting.

An alternative storage method for grain involves harvesting the entire plant, cutting it finely and packing it quickly in air-tight structures to undergo anaerobic lactic acid fermentation. Fermentation lasts from three to four weeks, after which the pH of the environment is too low for microbial activity, thus preserving the feed (Tremblay, 2008: 1). This is called silage and in Canada in 2001 over 85% of cereals devoted to silage was barley (Helm & Salmon, 2002: 1). This grain is preferred because of the higher average quality of the finished product noted by producers, but other grains used include corn, oats, and triticale (a hybrid of wheat and rye) (Helm & Salmon, 2002: 1).

According to AAFC (2009d), of some 21 million hectares of land devoted to grazing beef and dairy cattle and sheep[11] 6 million hectares is planted forage, or tame hay, and the rest is wild rangeland. As accurate yield data for wild plants are not readily available, the total area of pasture land will be determined by applying the yield for tame hay.

Table 3.80 shows the hay and pasture forage, added directly to tame hay consumption in table 3.83, and the silage consumed by cattle and sheep. Silage requires further transformation.

Table 3.80: Hay, pasture and silage required to support 2001 Canadian meat and dairy consumption.

ANIMAL	NUMBER FED	DRY HAY (T)	PASTURE (T)	SILAGE (T)
Beef cattle	2,240,000	919,000	2,700,000	2,720,000
Calves	101,000	4,950	16,400	2,520
Dairy cattle	479,000	492,000	156,000	1,420,000
Sheep	620,000	146,000	106,000	21,300
Total	n/a	**1,560,000**	**3,000,000**	4,170,000

For silage, a weighted average of the 2001 produced masses for barley, corn, and oats is applied against the silage requirement to apportion the share to each grain. As silage yields are not available from StatsCan (2009), studies conducted at an Alberta research farm provide a series of yield results for these grains grown under optimum conditions that are applied against their respective shares of silage (Baron, Okine & Dick, 2000: table 1 & table 6b). Table 3.81 shows the areas and resulting percent share. Barley, corn, and oats are applied directly to table 3.83.

[11] The remaining animals of concern here do not utilize pasture (StatsCan, 2005b).

Table 3.81: Calculation of production proportions for silage crops, 2001.

SILAGE	2001 PRODUCTION (T)	% OF TOTAL PRODUCTION
Barley	10,800,000	55
Corn	6,080,000	31
Oats	2,690,000	14
Total	19,600,000	100

Source: (StatsCan, 2009: survey 001-0010)

The area of grains required to produce the silage requirement determined in table 3.80 is calculated in table 3.82 and added to the total for that crop when cereals, legumes, and oilseed crops area gathered in table 3.83.

Table 3.82: Distribution of production required for silage crops.

GRAIN	% OF TOTAL PRODUCTION	SILAGE (T)
Silage	100	4,170,000
Barley	55	**2,310,000**
Corn	31	**1,290,000**
Oats	14	**572,000**

Source: (StatsCan, 2009: survey 001-0010)

3.2 Calculation of areas required to support 2001 household food consumption

The total masses of primary crops, the collection of all the bolded values from the tables in section 3.1, are found in tables 3.83, 3.84, and 3.85. The final areas that support domestic consumption are found by dividing the mass totals for each crop by the 2001 Canadian yields, as found in StatsCan (2009) and FAO (2009) resources. Table 3.83 shows the cereals, legumes, and oilseeds grown to support livestock production separately from those grown to supply people directly with those vegetable products. The total required area in table 3.83 is found by summing those columns (not shown) and applying the appropriate yield. The corn listed in table 3.83 is grain corn, which is accounted as animal feeds, as a source of cooking oil, for processed grain foods like breakfast cereals, and as the substitute for grains not grown in Canada, particularly rice.

Table 3.83: Final area calculations for 2001 consumption of cereals, legumes and oilseeds.

CROP	TOTALS FOR ANIMAL NEEDS FROM TABLES (T)	TOTALS FOR HUMAN NEEDS FROM FES & TABLES (T)	CROP YIELDS (T/HA)	TOTAL AREA (HA)
Barley	3,200,000	120,000	2.6	**1,280,000**
Barley (silage)	2,310,000	n/a	11.7	**198,000**
Canola	432,000	See 3.1.7	1.3	**332,000**
Corn (grain)	2,020,000	288,000	6.6	**442,000**
Corn (silage)	1,290,000	n/a	14.1	**91,600**
Dry hay (and pasture)	4,540,000	n/a	3.1	**1,490,000**
Mixed grains	79,300	0	2.8	**28,300**
Oats	862,000	29,700	2.2	**449,000**
Oats (silage)	572,000	n/a	13.1	**43,700**
Rye	0	2,520	1.9	**1,330**
Soybean	996,000	See 3.1.7	1.5	**664,000**
Sunflower	0	2,410	1.6	**1,560**
Wheat	1,160,000	1,170,000	1.9	**1,230,000**
Total	17,500,000	1,610,000	n/a	**6,270,000**

NOTES: i) n/a – not applicable.
ii) totals may not add due to rounding.

For tables 3.84 and 3.85 all of the primary crops listed are produced for human consumption with the exception of peas, which includes those used for livestock. The total areas are carried forward to the following section, where the final results are presented and discussed. The corn required to support consumption determined in section 3.1.6, vegetables, is listed in table 3.85 as sweet corn.

Table 3.84: Final area calculations for 2001 fruit consumption.

FRUIT	TOTALS FROM FES & TABLES (T)	CROP YIELDS (T/HA)	TOTAL AREA (HA)
Apples	2,200,000	8.4	**262,000**
Apricots	4,840	6.6	**733**
Blueberries	239,000	1.5	**159,000**
Cherries	39,100	5.8	**6,750**
Cranberries	123,000	14.6	**8,410**
Grapes	370,000	6.4	**57,800**
Melons	338,000	22.6	**15,000**
Peaches	169,000	9.3	**18,100**
Pears	127,000	11.1	**11,500**
Plums	36,700	4.5	**8,160**
Raspberries	51,500	3.8	**13,500**
Strawberries	125,000	4.4	**28,400**
Total	3,820,000	n/a	**589,000**

NOTES: i) n/a – not applicable.
ii) totals may not add due to rounding.

Table 3.85: Final area calculations for 2001 vegetable consumption.

VEGETABLE	TOTALS FROM FES & TABLES (T)	CROP YIELDS (T/HA)	REQUIRED AREA (HA)
Asparagus	210	2.4	**87**
Beans (dry)	59,400	1.8	**33,700**
Beans (green)	30,900	4.3	**7,180**
Beets	1,430	18.6	**77**
Broccoli	124,000	8.0	**15,500**
Cabbage	63,500	24.5	**2,590**
Carrots	190,000	35.4	**5,370**
Cauliflower	48,600	16.4	**2,960**
Celery	64,600	45.6	**1,420**
Corn (sweet)	105,000	9.2	**11,400**
Cucumbers	102,000	14.9	**6,830**
Lettuce	159,000	25.1	**6,340**
Mushrooms	57,100	217.0	**263**
Onions	168,000	36.0	**4,680**
Parsnips	281	14.6	**19**
Peas	145,000	4.4	**32,900**
Peppers	67,800	12.2	**5,560**
Potatoes	1,090,000	25.0	**43,700**
Radishes	12,400	6.9	**1,800**
Spinach	12,200	6.6	**1,850**
Tomatoes	313,000	52.3	**5,980**
Turnips	33,500	23.7	**1,410**
Total	2,850,000	n/a	**192,000**

NOTES: i) n/a – not applicable.
ii) totals may not add due to rounding.

4.0 Results and discussion

The areas actually under cultivation in 2001 for each crop are found in StatsCan (2009) and FAO (2009) resources. The self-sufficiency indicator (SSI) is found by determining the ratio of the areas actually under cultivation for primary agricultural production in Canada to those conceptually required to fulfill the dietary demands of its citizens. This is done for the consumption pattern evinced by the 2001 food expenditure survey (FES), as determined above.

4.1 The areas of Canadian self-sufficiency

In 2001, Canada had approximately 50,000,000 hectares of land suitable to agriculture, or about 5% of the total land mass (Hoffman et al., 2005: 4; 5, table 1; Kissinger & Rees, 2009: 2310). At that time, about 65% of that land, some 32,000,000 hectares, was under cultivation for cereals, legumes, and oilseeds (StatsCan, 2009). Table 4.1 shows the SSI results for these crops.

Table 4.1: Final areas for cereals, legumes and oilseeds, 2001.

CROP	CONSUMPTION AREA (HA)	PRODUCTION AREA (HA)	SSI
Barley	1,470,000	4,700,000	3.2
Canola	332,000	3,830,000	11.5
Corn	442,000	1,290,000	2.9
Hay & pasture	1,490,000	7,660,000	5.2
Mixed grains	28,300	364,000	12.9
Oats	449,000	1,910,000	4.3
Rye	1,330	181,000	137
Soybean	664,000	1,080,000	1.6
Sunflower	1,560	72,800	46.7
Wheat	1,230,000	11,000,000	8.9
Total	6,100,000	32,000,000	5.3

NOTE: numbers may not add due to rounding.

Table 4.1 shows that after conceptually supplying Canadian food consumption over five times the land in question supports crops destined for other uses, mostly trade, but also building materials, biofuels, bioplastics, and other novel uses (Junkins et al., 2005: 18). This is unsurprising since Canada is a major supplier of agricultural products to the world market, in 2001 especially as the largest exporter of oats and canola, second-largest of wheat, third of rye, and fifth of barley (FAO, 2009); exports of raw grain crops alone accounted for 15% of the value of all exports of domestic agri-food products in 2001 (Industry Canada, 2008).

Since calculation of the SSI for crops is in part a function of market forces at work within the country, with respect that conceptually required areas are extrapolated from existing producer choices, and country-specific yields, it can be more illustrative of the usage of productive lands than methods better suited to cross-country comparison. In their application of the EF to Prairie agriculture, Kissinger and Rees find 62% of cropland and about 45% of meat footprints, totalling about 28 million hectares or half of the total footprint, are exported[12] (2009: 2312-2313). However, this is not a real area and danger exists that if it is seen that way then, for example, efforts to make Prairie agriculture more sustainable may be equally directed towards influencing Canadian consumption patterns as towards increasing the food security of those nations dependant on Canadian exports. The possibility of assigning such "`false concreteness"' to EF

[12] On average for the years between 1989-2007 (Kissinger & Rees, 2009: 2311).

results has been recognized as a concern not only of the lay public and politicians, but apparently also of trained environmentalists and scholars (van den Bergh & Verbruggen, 1999: 64, single quotes in the original).

Through integration with the AEI, the SSI can reveal the impacts of Canada's contributions to the global agri-food market. The implementation of AAFC's indicator set positively shows long-underway declines in risk of water, wind, and tillage soil erosion (Lobb, 2005: 103, table 13-3; Rostad & Padbury, 2005: 98, table 13-2; van Vliet, Padbury, Rees & Matin, 2005: 92, table 13-1), improvements in soil organic carbon content (McConkey, Hutchinson, Smith, Grant & Desjardins, 2005: 108; 110, table 14-1), and declines in soil salinity (Wiebe, Eilers, Eilers & Brierley, 2005: 116, table 15-1). However, there is a worrying on-going trend towards increased risk of nutrient run-off causing nitrogen contamination to ground- and surface waters, a consequence of agricultural intensification and changing producer choices (Drury et al., 2005: 72, table 9-2).

The trend towards further converting summerfallow land to intensive monoculture (Eilers & Huffman, 2005: 44) and generally switching from cereal crops to legumes or row crops are economically enhancing strategies that result in soil nutrient accumulation, nonetheless both are supported by government policies and marketing efforts (Junkins et al., 2005: 19). The oversupply of field crops, from the point of view of potential domestic requirements, revealed by the SSI in table 4.1 suggests that producers could be further influenced to adopt production of novel foods for domestic markets. As an instance, the intensive corn production in Ontario and Quebec, which together comprise over 95% of the Canadian growing area, and the increase in legumes planted in those provinces are thought greatly responsible for the dramatic increase in farms at higher risk of nitrogen run-off (Drury et al., 2005: 72, 74; StatsCan, 2009: survey 001-0010). Since self-sufficient production can be recognized easily in table 4.1, some fraction of production could be identified as superfluous and price supports or greater marketing and promotion can be designed to encourage diversification or new crop development. For example, this could provide the impetus to bring "un-official" grains like kamut, spelt, and quinoa into the Canada Grain Act so producers can obtain the same income guarantees that traditional commercial grains enjoy (CGC, 2009: ¶10).

Indeed, AAFC suggests producers should exploit the desire that more affluent peoples have for a diet that is increasingly guided by personal taste, variety, convenience, and an enhanced awareness that less intensive production practises such as organic agriculture can improve the immediate environment (Gerbens-Leenes et al., 2002: 48; Junkins et al., 2005: 18-19, 20). As diets become more affluent, consumption of fresh fruits and vegetables rises (Gerbens-Leenes et al., 2002: 55). There is thus both reason and opportunity to increase fruit and vegetable production in an effort to achieve a sustainable agri-food system, as shown in table 4.2 and 4.3, respectively.

Table 4.2 shows self-sufficiency in fruit can be achieved by switching just 1% of the 2001 total area under cultivation in Canada from some other use. The SSI reveals Canadians consumed fruit in amounts that if produced by domestically cultivatable species would require 1.1 million hectares, over 10 times the area actually under cultivation for fruit in 2001. Despite this, in 2001 there was in fact a decline in cultivated area of about 1% from the previous year, although the farm-gate value of production was up 7% (StatsCan, 2002: 5).

Table 4.2: Final areas for fruits, 2001.

CROP	CONSUMPTION AREA (HA)	PRODUCTION AREA (HA)	SSI
Apples	262,000	25,800	0.10
Apricots	733	208	0.28
Blueberries	159,000	44,000	0.28
Cherries	6,750	1,930	0.29
Cranberries	8,410	2,380	0.28
Grapes	57,800	10,600	0.18
Melons	15,000	550	0.04
Peaches	18,100	3,300	0.18
Pears	11,500	1,570	0.14
Plums	8,160	801	0.10
Raspberries	13,500	3,840	0.28
Strawberries	28,400	6,000	0.21
Total	589,000	101,000	0.17

NOTE: numbers may not add due to rounding.

There is little overt mention of whether or not AAFC's AEI are applied specifically to fruit production in Canada and considering the relatively low area under cultivation shown in table 4.2 compared to that shown in table 4.1, a focus on field crops is understandable. One goal of this work is to incorporate additional social aspects into Canada's sustainable agricultural development polices. An imperative to effect positive changes in society as a whole is implied by the word "development" (Daly, 1987: 323; Niu et al., 1993: 180) and suggests another use for the SSI: linking the impact of agricultural land use change to agri-food sustainability.

Canadians have historically been among the world's largest consumers of fruit and fruit juice, for instance consuming about twice as much of the latter as Americans do (Lee, Brown & Seale jr., 1992: 255). Yet if the mass of fruit consumed domestically in 2001 were re-distributed proportionately to currently produced species, not a single crop could meet the demand (table 4.2). The distribution of fruit-growing areas in 2001 was limited to four main regions in the following proportions: 30% grown in Ontario, 27% in Quebec, 21% in British Columbia, and 12% in Nova Scotia (StatsCan, 2005: 5). There is a long-term decline in the areas devoted to fruits in Canada (AAFC, 2008b: 2-3, table 1; Krueger, 1978: 179), as urbanization continues to claim the higher-quality farm land most suitable to its cultivation (Hoffman et al., 2005: 8). This is of particular concern in Ontario, which contains 56% of the premier agricultural land in Canada, as a high proportion of that land is in the south-western Golden Horseshoe region that is also home to most of Canada's urban lands (Hoffman et al., 2005: 5, 7).

There is here a confluence of social and environmental issues. Urban sprawl is especially contentious where some fruit is grown since those areas possess specialized conditions that do not exist elsewhere (Hoffman et al., 2005:

8). However, urbanization continues apace increasing reliance on imports, the chief supplier of which is the US at about 80%, followed by nations of the Southern Hemisphere who typically supply when domestic crops are out of season (AAFC, 2007b: 9, 14). Together, this means as Canada permanently loses fruit production capacity to possibly unsustainable land use changes, there is an increasing reliance on foreign sources. As importation rises, along with the associated pollution and GHG emissions, so does the general unsustainability of the agri-food system as it becomes less self-sufficient.

Table 4.3 shows that for the most part, Canada is self-sufficient in vegetable production, with production about 2.5 times total conceptual demand. Although there are several individual items that are potentially under-supplied, this methodology extrapolates producer response to market forces, not consumer demand for specific products and so should not necessarily suggest heightening production of particular items. However, as a great many vegetables are row crops that provide less surface cover, growing them at all raises the risk of erosion (Huffman et al., 2006: 67). The SSI should be seen here as cautionary; if AEI results tend to prescribe against vegetable cultivation as a mitigation measure for certain impacts (e.g. Lobb, 2005: 106, ¶5), it should be considered only until it impinges on self-sufficiency. The long-term economic costs of import-reliance can be balanced against those of other mitigation measures or research into practices that, for instance, increase soil cover like intercropping. Finally, since vegetables are grown in many of the same areas as fruits, they are at similar risk to urbanization.

Table 4.3: Final areas for vegetables, 2001.

CROPS	CONS. AREA (HA)	PROD. AREA (HA)	SSI
Asparagus	87	1,630	18.6
Beans (dry)	33,700	185,000	5.47
Beans (green)	7,180	12,100	1.69
Beets	77	1,160	15.0
Broccoli	15,500	4,050	0.26
Cabbage	2,590	6,250	2.41
Carrots	5,370	9,380	1.75
Cauliflower	2,960	2,880	0.97
Celery	1,420	794	0.56
Corn (sweet)	11,400	35,400	3.09
Cucumbers	6,830	12,800	1.88
Lettuce	6,340	3,500	0.55
Mushrooms	263	398	1.51
Onions	4,680	5,420	1.16
Parsnips	19	288	15.0
Peas	32,900	17,200	0.52
Peppers	5,560	2,590	0.47
Potatoes	43,700	169,000	3.88
Radishes	1,800	983	0.55
Spinach	1,850	646	0.35
Tomatoes	5,980	13,600	2.28
Turnips	1,410	2,270	1.60
Total	192,000	487,000	2.54

NOTE: numbers may not add due to rounding.

4.2 Inclusiveness of results

The 2001 FES contains the consumption records for some 1995 different agri-food products. This analysis attempts to capture as many as realistically possible, especially those conforming to the recommendations of Canada's food guide (Health Canada, 2008b). Table 4.4 shows the FES food categories, the totals consumed and the totals accounted for by the SSI, listed according to whether the item is reported in volume units (millions of litres) or mass (millions of tonnes).

Table 4.4: Total volumes and masses from the FES and accounted by the SSI.

FES ITEM	FES (ML)	SSI (ML)	SSI (%)	FES (MT)	SSI (MT)	SSI (%)
Meat & fish	0	0	0	1,700	1,700	99
Dairy	2,700	2,400	87	310	310	100
Cereals	30	30	100	1,600	1,200	77
Fruit	1,100	1,000	96	1,300	1,300	100
Vegetables	710	450	64	1,800	1,800	100
Fats & oils	78	78	100	110	107	95
Nuts	0	0	0	42	0	0
Sugar	18	0	0	310	0	0
Coffee & tea	0	0	0	72	0	0
Other	2,600	0	0	600	140	24
Total	7,200	3,900	55	7,800	6,500	84

Source: (StatsCan, 2003b).

There are a number of factors affecting the seemingly low inclusion of volume-measured foodstuffs. Mainly it is the "other" category, which accounts for about 36% of the total volume and is made up of soups that do not belong elsewhere (cream soups, turtle soup, cheddar cheese soup, etc.), infant foods and formulas, carbonated beverages, and fruit drinks (liquor mixes, lemonade, Gatorade®, etc.). The low apparent response for volume-measured vegetables is explained in that this group comprises prepared salad dressings, "other condiments," which includes vinegar, and "other sauces" (guacamole, rib and wing sauces, taco, teriyaki and soya sauces, etc.), the latter of which alone accounts for 36% of the total volume of vegetables. The cereals and dairy unaccounted for are sweetened products, such as cakes and ice cream respectively, that are not part of the analysis. Numerically, 1225 items were included in the analysis, or 61%. If "non-food" items like beverages, spices, salt, herbs, jelly powders, gelatine and infant formulas are removed from the count, the share rises to 66%.

In calculating the number of animals required from the mass of cuts of meat there are considerable differences in the numbers; for example, half the number of cattle is required to supply offal as hip cuts (table 3.5) and over nine times the number of swine are required to supply loin cuts as to supply the mass of belly cuts (table 3.12). This is mainly an artefact of the FES in that the ordinal rank of each cut from the survey is the same as that of the required animals before the addition of masses as determined by the method (i.e. the additional masses from prepared meat products, etc.). Accounting for the disposition of the discrepancy is beyond the scope of this work, but possible explanations include exports and pet foods.

5.0 Conclusions

Canada does not grow what it eats. There is, on first glance, a surfeit of land available to conceptually supply its citizens with food. Some foodstuffs derived from the field crops listed in table 4.1 could be consumed from domestic sources in amounts at least 50% greater than in 2001 and table 4.3 shows there was over 60% more vegetable area available than "required." The unsustainability of the current Canadian consumption pattern is highly apparent from table 4.2, which shows over 5 times the current area would need to be brought under cultivation to meet consumption levels with domestically produced fruit. Although this only amounts to 1% of the available agricultural land, the land most suited to fruit farming is also that most at risk of loss to land use change (Hoffman et al., 2005: 7-8) and has long be declining (Krueger, 1978: 179). This is a permanent loss of carrying capacity and represents increasing Canadian dependence on the globalized agri-food system, which is thought by many to be unsustainable.

Of course, Canada's farmers should and do exploit the nation's comparative advantage for field crop production, primarily in the Prairies but also increasingly in the Central provinces, and so with good reason the initial AEI are focused on ascertaining the impacts of that production. The sustainable development definition on which AAFC bases its choice of indicators (Lefebvre, 2005: 2) specifies the natural resources that agriculture depends on as needing protection. Without including domestic demand in the decision-making process the AEI results can have a prescriptive effect on cropping choices while protecting that advantage or those resources; this, in turn, can cause Canadian consumers to become more reliant on foreign sources of food for a nutritionally complete diet. Likewise, the AEI are not likely to be influential on policies that affect land loss, namely urbanization.

Recognizing consumer demand as a pressure variable highlights socially desirable outcomes, such as preserving prime land, and incorporating national agri-food self-sufficiency into the AEI broadens the options for environmental, social, and economic responses within the DSR framework used in most OECD countries, including Canada. Douglass' (1984: 07) caution that sustainability requires a delimited temporal scale within which agricultural supply and demand for a given socio-economic system are closely matched is complemented by Conway's (1985: 34) assertion that due to the hierarchical nature of agroecosystems a response at one level in the system cannot easily predict the outcomes at another one. However, the SSI uses average household consumption and can therefore be disaggregated to agree with intervening spatial scales.

One hoped-for contribution of this study to the methodology is in using surveyed consumer preferences for food as a way to help construct more realistic assessments of agri-food system sustainability. A nationally-weighted dataset was used here, which may not be representative of some urban centres that have large, culturally distinct populations whose dietary preference is markedly different. However, resting the method on surveyed data is claimed as an improvement since applying re-weighted or new data is easily done if the scale or the scope of the study changes. This is unlike studies using the apparent disappearance residuals, which are derived from highly aggregated data mostly influenced by collective producer decisions and international trade conditions. Further, with respect to such top-down assessments, as the primary crops move through the processing chain they are subject to wastage or process losses; accounting all losses for the same number of final products as analyzed here is likely to be immensely complicated and introduce additional uncertainty.

Nonetheless, there are several points in this study where uncertainty is introduced, including the following: Prepared meat products were assumed to consist solely of meat, but meat pies, for instance, have a dough crust. An exploration of the exact variability in yields of dairy products was not made; this may be important for, say, cheese made from the milk of animals other than cattle. The fate of laying hens is uncertain; reputable information about if or where layers enter the food chain was not forthcoming, although since layers amount to less than 4% of the birds required for meat (tables 3.17 & 3.21) this is not an egregious instance of double-counting in any case. There are certainly innumerable bread recipes and it is likely that there is enough variation in ingredient proportions among them to produce a range of input quantities, rather than the single values used here. There is an assumption that 2001 yields were not unusual and that there was no radical shift in production choices from past years.

There are two methods by which the distributional proportions shown in tables 3.36, 3.53, 3.66, 3.74, and 3.81 could be calculated. After the final masses of foodstuffs are calculated, those crops that are not domestically grown are allocated to those that are according to the fraction of the mass of each crop that was produced in 2001. Allocating those fractions according to area provides quite different results because yields vary considerably between crops. A farmer has to devote a larger area to a low-yield crop than to higher-yielding one to obtain the same mass of both, thus area is not a reflection of market share. Thus, for example, using area leads to the conclusion that 800,000 hectares of blueberries, almost 6 times that of apples, would be required for that crop's share, while using the mass fraction suggests apples be produced in amounts 1.6 times that of blueberries. The mass of apples produced in 2001 was almost 7 times that of blueberries (StatsCan, 2002: 18, table 2), suggesting there is still a limitation with this aspect of the method.

Canada is a large country and regional trading with proximate American states in many cases is more desirable than cross-country transport of similar foods. Care is taken here not to imply that self-sufficiency within an artificial border is a necessary condition of sustainability, but rather that those cases where Canada is far, or is moving away, from self-sufficiency deserve extra attention.

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Appendix 1

Appendix E **Food Code Descriptions**

Food code	Description
F004	**Beef hip cuts (except shank cuts) - fresh or frozen**
F004	Beef Swiss steaks - fresh or frozen
F004	Minute steak - fresh or frozen
F004	Beef Tournedos - fresh or frozen
F004	Beef sirloin tip cuts - fresh or frozen
F004	Beef sandwich steaks - fresh or frozen
F004	Beef rump cuts - fresh or frozen
F004	Beef round cuts (including eye-of-round) - fresh or frozen
F004	Beef Chinese fondue - fresh or frozen
F004	Beef Boston steaks - fresh or frozen
F004	French beef - fresh or frozen
F005	**Beef loin cuts - fresh or frozen**
F005	Beef brochettes (fresh or frozen)
F005	Beef t-bone steaks - fresh or frozen
F005	Filet mignon - fresh or frozen
F005	Beef wing/club steaks - fresh or frozen
F005	Beef tenderloin cuts - fresh or frozen
F005	Beef strip/New York/top cuts - fresh or frozen
F005	Beef pin bone steaks - fresh or frozen
F005	Baron of beef - fresh or frozen
F005	Beef porterhouse steaks - fresh or frozen
F006	**Beef rib cuts - fresh or frozen**
F006	Beef rib cuts (including standing, rolled, or prime) - fresh or frozen
F006	Beef rib eye/delmonico/spencer cuts - fresh or frozen
F006	Beefeater roast - fresh or frozen beef
F007	**Beef chuck cuts (except shank cuts) - fresh or frozen**
F007	Beef shoulder cuts - fresh or frozen
F007	Beef short-rib roasts - fresh or frozen
F007	Beef blade cuts - fresh or frozen
F007	Beef chuck cuts - fresh or frozen
F007	Beef cross-cut rib cuts - fresh or frozen
F008	**Stewing beef - fresh or frozen**
F008	Beef pieces - fresh or frozen
F009	**Ground beef (including patties) - fresh or frozen**
F009	Beef hamburger - fresh or frozen
F009	Beef patties - fresh or frozen
F009	Beef ground - fresh or frozen
F009	Beef steakettes - fresh or frozen

F015	**Beef carcasses and primal portions - fresh or frozen**
F015	Beef, other (incl. brisket, plate, flank, shank cuts) - fresh or frozen
F015	Beef hinds - fresh or frozen
F015	Beef shank primal portions - fresh or frozen
F015	Beef rib primal portions - fresh or frozen
F015	Beef plate primal portions - fresh or frozen
F015	Beef sides - fresh or frozen
F015	Beef fronts - fresh or frozen
F015	Beef flank primal portions - fresh or frozen
F015	Beef chuck primal portions - fresh or frozen
F015	Beef brisket primal portions - fresh or frozen
F015	Beef hip primal portions - fresh or frozen
F015	Beef loin primal portions - fresh or frozen
F015	Beef brisket cuts - fresh or frozen
F015	Beef short/braising ribs - fresh or frozen
F015	Beef shank cuts - fresh or frozen
F015	Beef plate cuts - fresh or frozen
F015	Beef flank cuts - fresh or frozen
F015	Beef london broil - fresh or frozen
F026	**Pork leg cuts (except hocks) - fresh or frozen**
F026	Pork shank end roasts - fresh or frozen
F026	Pork leg roasts - fresh or frozen
F026	Pork centre ham cuts - fresh or frozen
F027	**Pork loin cuts - fresh or frozen**
F027	Pork riblets - fresh or frozen
F027	Pork steak - fresh or frozen
F027	Pork loin roasts (including crown) - fresh or frozen
F027	Pork loin chops (rib, country-style or butterfly) - fresh or frozen
F027	Pork brochettes - fresh or frozen
F027	Pork back ribs - fresh or frozen
F027	Breaded pork cutlets - fresh or frozen
F027	Pork tenderloin - fresh or frozen
F028	**Pork belly cuts - fresh or frozen**
F028	Pork side spareribs - fresh or frozen
F028	Side pork (belly cuts) - fresh or frozen
F029	**Pork shoulder cuts (except hocks) - fresh or frozen**
F029	Pork butt cuts (including Boston-style) - fresh or frozen
F029	Pork shoulder cuts (including New York or Montreal-style) - fresh or frozen
F029	Porcetta (Italian pork roast) - fresh or frozen
F029	Picnic shoulder - fresh or frozen

F035	**Pork carcasses and primal portions - fresh or frozen**
F035	Pork - other (including hocks) - fresh or frozen
F035	Pork shoulders - fresh or frozen
F035	Hog carcasses - fresh or frozen
F035	Hog sides - fresh or frozen
F035	Pork bellies - fresh or frozen
F035	Pork legs - fresh or frozen
F035	Pork loins - fresh or frozen
F035	Pork hocks - fresh or frozen
F035	Ground pork - fresh or frozen
F046	**Chicken (including fowl) - fresh or frozen**
F046	Boneless chicken - fresh or frozen
F046	Stewers (chicken) - fresh or frozen
F046	Roasters - chicken - fresh or frozen
F046	Cornish hens - fresh or frozen
F046	Fowl - fresh or frozen
F046	Chicken brochettes - fresh or frozen
F046	Capon chicken - fresh or frozen
F046	Breaded chicken cutlets - fresh or frozen
F046	Broiler chicken - fresh or frozen
F046	Chicken wings (except cooked) - fresh or frozen
F047	**Turkey - fresh or frozen**
F049	**Poultry meat and offal from poultry - other - fresh or frozen**
F049	Quail - fresh or frozen
F049	Ducks - fresh or frozen
F049	Geese - fresh or frozen
F049	Giblets - fresh or frozen
F049	Pheasants - fresh or frozen
F049	Poultry liver - fresh or frozen
F061	**Veal - fresh or frozen**
F061	Osso bucco - fresh or frozen
F061	Veal scaloppini - fresh or frozen
F061	Ground veal - fresh or frozen
F071	**Liver from mammals - fresh or frozen**
F074	**Offal from mammals - other - fresh or frozen**
F074	Stomachs (tripe) - fresh or frozen
F074	Ox tails - fresh or frozen
F074	Tongues - fresh or frozen
F074	Sweetbreads - fresh or frozen
F074	Soup bones
F074	Knuckles - fresh or frozen
F074	Feet - fresh or frozen
F074	Kidneys - fresh or frozen
F074	Tails - fresh or frozen
F074	Hearts - fresh or frozen
F074	Marrow bones - fresh or frozen

F076	**Lamb and mutton - fresh or frozen**
F076	Meat (except poultry) - other - fresh or frozen
F076	Lamb - fresh or frozen
F076	Mutton - fresh or frozen
F076	Goat meat - fresh or frozen
F076	Venison - fresh or frozen
F076	Horse meat - fresh or frozen
F076	Frogs legs - fresh or frozen
F076	Caribou meat - fresh or frozen
F076	Buffalo meat - fresh or frozen
F076	Rabbit meat - fresh or frozen
F082	**Bacon**
F082	Peameal bacon (back bacon)
F083	**Ham (except cooked ham)**
F083	Cottage rolls
F083	Picnic ham
F083	Uncooked ham
F083	Smoked ham
F083	Picnic shoulder ham
F083	Ham slices (steaks)
F083	Ham shanks
F083	Ham - pickled (except canned)
F083	Ham butts - uncooked
F085	**Cured meat - other**
F085	Smoked poultry meat
F085	Corned beef - brisket
F085	Corned beef - sweet pickled
F085	Cured bacon rinds
F085	Cured pigs feet (edible offal)
F085	Jerked meat – (jerky) (except canned)
F085	Pail salt beef
F085	Pork hocks (edible offal), (except canned) - pickled
F085	Salted pork
F085	Smoked beef, except pre-cooked
F085	Sunrise Salt Meat (TM)
F091	**Uncooked sausage**
F091	Beef and pork sausage - uncooked, chilled or frozen
F091	Beef sausage - uncooked, chilled or frozen
F091	Breakfast sausage - uncooked
F091	Country-style sausage - uncooked
F091	English bangers - uncooked
F091	Farmer style sausage uncooked - chilled or frozen
F091	Link sausage - uncooked
F091	Longanisa - uncooked
F091	Oktoberfest sausage - uncooked
F091	Pork sausage - uncooked, chilled or frozen

F092	**Bologna**
F093	**Wieners (except canned)**
F093	Wieners (made with chicken) - except canned
F093	BBQ wieners - except canned
F093	Frankfurters (except canned)
F093	Campfire garlic - except canned
F096	**Cooked/cured sausage - other**
F096	Pancetta
F096	Liver cheese (liver loaf)
F096	Leona style sausage
F096	Liver sausages (except canned)
F096	Liverwurst sausage
F096	Lunenburg pudding
F096	Merguez
F096	Milano sausage
F096	Mortadella sausage
F096	White pudding sausage (except canned)
F096	Pastrami sausage (except canned)
F096	Bratwurst sausage
F096	Pepperoni sausage
F096	Polish/summer sausage
F096	Salami
F096	Saveloy sausage
F096	Vienna sausage
F096	Kolbassa sausage
F096	Summer sausage
F096	Black pudding sausage - cooked or cured (except canned)
F096	Brockwurst sausage
F096	Andouillettes (except canned)
F096	Bavarian sausage
F096	Knackwurst sausage (except canned)
F096	Beer sausage
F096	Blood pudding sausage
F096	Braunschweiger sausage
F096	Capicolla sausage
F096	Holsteiner sausage
F096	Beef smokies sausage - cooked or cured
F096	Hot italian sausage
F096	Chinese sausage
F096	Har coil sausage
F096	Goteborg sausage
F096	Genoa sausage
F096	Garlic ring sausage
F096	Dry sausage
F096	Mastro (TM)

F097	**Cooked (boiled) ham**
F097	Luncheon ham
F097	Prosciutto (except canned)
F097	Sliced ham
F100	**Ready-cooked meat - hot - other**
F100	Other ready-cooked meat (except hot) (includes cold cuts)
F100	Fried chicken - hot
F100	Chicken wings (hot)
F100	Turkey pieces - hot
F100	Meat loaf - hot
F100	Cooked whole turkey - hot
F100	Chicken nuggets (hot)
F100	Chicken burgers - hot
F100	Barbequed or roasted poultry meat - hot
F100	Chicken strips (hot)
F100	Barbequed or roasted meats - hot
F100	Roast chicken - hot (excluding whole bbq)
F100	Roast chicken - frozen
F100	Luncheon loaf (except canned)
F100	Luncheon meats (including sliced and prepackaged)
F100	Macaroni and cheese loaf (mainly meat) (including sliced and prepackaged)
F100	Turkey rolls - pre-cooked - frozen
F100	Meat (except canned) - pre-cooked - frozen
F100	Meat and olive loaf (except canned)
F100	Meat loaves and jellied meats (except canned)
F100	Mock chicken (except canned)
F100	Pimento loaf (except canned) - pickled
F100	Scotch eggs
F100	Smoked beef - pre-cooked
F100	Spiced beef (including sliced and prepackaged)
F100	Jellied veal (except canned)
F100	Chicken wings - cooked (except heated)
F100	Pickle and pimento ham loaf (except canned)
F100	Cooked pork roast
F100	Ham loaf (except canned)
F100	Fried chicken - frozen
F100	Corned beef (except canned)
F100	Cooked turkey pieces
F100	Chicken strips
F100	Chicken nuggets - ready-cooked
F100	Chicken burgers
F100	Chicken - frozen cooked
F100	Cha sui (barbequed pork) - hot or cold
F100	Boil-in-a-bag meat (except ham) (except canned)

F100	Barbequed or roasted poultry meat (except canned)
F100	Barbequed or roasted meats (except hot)
F100	Jellied tongue (except canned)
F100	Cooked whole turkey or sliced turkey
F101	**Meat preparations (except hot) - other**
F101	Meat preparations - hot - other
F101	Sweet and sour spareribs (except hot)
F101	Solid meat essences
F101	Skillet strips
F101	Sausage meat - fresh or frozen
F101	Sausage rolls - fresh
F101	Tourtiere
F101	Reuben
F101	Powdered meat essences
F101	Poultry pastes (except canned)
F101	Potted meats (except canned)
F101	Meat soup stock (except canned)
F101	Meat salads
F101	Chicken pot pies (except pre-cooked frozen)
F101	Meat pies (including poultry) - fresh
F101	Scrapple (except canned)
F101	Beef stew - dried
F101	Cooked meat offal in aspic or coated with fat (except canned)
F101	Dongo-dongo
F101	Haggis
F101	Head cheese (cretons) and scrapple (except canned)
F101	Jamaican patty
F101	Meat loaf mix (beef, pork, veal)
F101	Meat pastes (except canned)
F101	Meat pates (except canned)
F101	Beef and kidney pies (except canned)
F101	Beef & kidney pie - hot
F101	Poultry pastes (hot)
F101	Tourtiere - hot
F101	Sweet & sour spareribs - hot
F101	Sausage rolls - hot
F101	Sausage meat - hot
F101	Meat soup stock - hot
F101	Meat pies (including poultry) - hot
F101	Meat pastes (hot)
F101	Chicken pot pies - hot
F101	Jamaican patty (hot)

F108	**Hams - canned**
F108	Meat stews - canned
F108	Prosciutto - canned
F108	Picnic hams - canned
F108	Beef ragout - canned
F108	Beef stew - canned
F108	Irish stew - canned
F108	Meat ball stew - canned
F110	**Meat and meat preparations (except infant foods) - other - canned**
F110	Meat-filled cannelloni - canned
F110	Pate de foie gras - canned
F110	Oxtails - canned
F110	Ox (beef) tongues - canned
F110	Pork sausage - canned
F110	Meat-filled ravioli - canned
F110	Spiced pork and ham - canned
F110	Meat balls and gravy (beef) - canned
F110	Meat balls and gravy, n.e.s. - canned
F110	Mutton or lamb (except infant foods) - canned
F110	Pork spread - canned
F110	Spiced beef - canned
F110	Steak and kidney pie - canned
F110	Truffles with pate de foie de gras - canned
F110	Turkeys - canned
F110	Veal spread - canned
F110	Wieners and beans - canned
F110	Wieners or frankfurters - canned
F110	Liver paste - canned
F110	Smoked bacon rinds - canned
F110	Boned chicken - canned
F110	Ham spread - canned
F110	Bacon - canned
F110	Beef dinners - canned
F110	Beef fluid (meat extract) - canned
F110	Beef hash (except infant foods) - canned
F110	Beef steak and onions - canned
F110	Braised steak - canned
F110	Brawn - canned
F110	Chicken loaves - canned
F110	Flakes of ham - canned
F110	Flakes of turkey - canned
F110	Beef paste - canned
F110	Meat gravy - canned
F110	Chicken-a-la-king - canned

F110	Flakes of corned beef - canned
F110	Flakes of chicken - canned
F110	Deviled ham - canned
F110	Corned beef - canned
F110	Cooked fancy meats (edible offal) (except infant foods) - canned
F110	Cocktail sausages - canned
F114	**Cod - fresh or frozen**
F114	Atlantic cod - fresh or frozen
F114	Bakala fish (cod) - fresh or frozen
F114	Gray cod - fresh or frozen
F114	Rock cod - fresh or frozen
F115	**Flounder and sole - fresh or frozen**
F115	Petrale - fresh or frozen
F115	Brill - fresh or frozen fish
F115	Plaice - fresh or frozen
F115	Arrowtooth - fresh or frozen
F115	Dab - fresh or frozen fish
F115	Pacific turbot - fresh or frozen
F116	**Haddock - fresh or frozen**
F123	**Salmon - fresh or frozen**
F123	Kokanees - fresh or frozen
F123	Salmon fillets - fresh or frozen
F125	**Sea fish - other - fresh or frozen**
F125	Sea smelt - fresh or frozen
F125	Sea bass - fresh or frozen
F125	Sardines (sardina) - fresh or frozen
F125	Sablefish - fresh or frozen
F125	Rosefish - fresh or frozen fish
F125	Shad - fresh or frozen fish
F125	Pollock (bluefish) - fresh or frozen
F125	Steelhead trout - fresh or frozen
F125	Ocean perch - fresh or frozen fish
F125	Redfish - fresh or frozen fish
F125	Shark - fresh or frozen
F125	Silverfish
F125	Snappers - fresh or frozen
F125	Ocean catfish (wolf fish) - fresh or frozen
F125	Swordfish (brandbill) - fresh or frozen
F125	Tilapia
F125	Tomcod - fresh or frozen fish
F125	Tuna - fresh or frozen sea fish
F125	Turbot (Greenland halibut) - fresh or frozen
F125	Pilchard - fresh or frozen fish
F125	Skate (wings) - fresh or frozen fish
F125	Fish piece (log cut)
F125	Atlantic silverside

F125	Billfish (skipper) - fresh or frozen
F125	Blue runner fish
F125	Boccacio - fresh or frozen
F125	Bream - fresh or frozen
F125	Capelin (caplin) - fresh or frozen fish
F125	Capucettes
F125	Cultus cod - fresh or frozen fish
F125	Milkfish
F125	Eulachon (candlefish) - fresh or frozen
F125	Alewife (gasparot, gaspareau, kyak) - fresh or frozen fish
F125	Flatfish - fresh or frozen fish
F125	Groundfish - fresh or frozen
F125	Hake (ling) - fresh or frozen
F125	Halibut (flitches) - fresh or frozen
F125	Herring - fresh or frozen fish
F125	Launce, sand - fresh or frozen fish
F125	Lingcod (cultus cod) - fresh or frozen
F125	Puslier (caesio) fish
F125	Mackerel - fresh or frozen
F125	Cusk - fresh or frozen fish
F129	**Freshwater fish - fresh or frozen**
F129	Char - fresh or frozen fish
F129	Menominee - fresh or frozen fish
F129	Mooneye - fresh or frozen fish
F129	Mullet - fresh or frozen fish
F129	Muskellunge (maskinonge, lunge) - fresh or frozen
F129	Pickerel (blue pike, pikeperch, dore, walleye) - fresh or frozen
F129	Pike - fresh or frozen freshwater fish
F129	Pilot fish - fresh or frozen
F129	Powan - fresh or frozen fish
F129	Redfin - fresh or frozen fish
F129	Waterbelly - fresh or frozen fish
F129	Redhorse - fresh or frozen fish
F129	Roundfish - fresh or frozen fish
F129	Sauger - fresh or frozen fish
F129	Smelt - fresh or frozen
F129	Sturgeon - fresh or frozen
F129	Sucker - fresh or frozen fish
F129	Sunfish (pumpkinseed) - fresh or frozen
F129	Trout (togue, touladi) - fresh or frozen
F129	Tullibee (cisco, lake chub, lake herring, kiyi, blueback) - fresh or frozen
F129	Ling - fresh or frozen
F129	Whitefish - fresh or frozen
F129	Chub - fresh or frozen fish
F129	Yellow perch - fresh or frozen fish

F129	Barbotte - fresh or frozen
F129	Bass (black crappie, calico, redeye) - fresh or frozen
F129	Bloat (bloater) - fresh or frozen
F129	Bluegill - fresh or frozen
F129	Blues - fresh or frozen
F129	Buffalofish - fresh or frozen
F129	Bullhead - fresh or frozen fish
F129	Coregone - fresh or frozen fish
F129	Buffalofish (carpsucker) - fresh or frozen fish
F129	Laurette - fresh or frozen fish
F129	Crappies - fresh or frozen fish
F129	Drum (sheephead) - fresh or frozen fish
F129	Frost fish - fresh or frozen
F129	Gizzard - fresh or frozen fish
F129	Goldeye - fresh or frozen fish
F129	Grayling - fresh or frozen fish
F129	Greaser - fresh or frozen fish
F129	Inconnu (connie) - fresh or frozen fish
F129	Lamprey (lamper) - fresh or frozen
F129	Carp - fresh or frozen fish
F135	**Fish portions - pre-cooked frozen**
F135	Breaded fish portions - pre-cooked frozen
F135	Fish ball - pre-cooked frozen
F135	Fish burgers - pre-cooked frozen
F135	Fish portions in batter - pre-cooked frozen
F135	Fish sticks - pre-cooked frozen
F135	Lemon fillets - pre-cooked frozen
F135	High Liner fish (TM)
F140	**Cured fish**
F140	Ragoonb
F140	Mackerel - smoked, salted, dried, vinegar cured or pickled
F140	Tullibee - smoked, salted, dried, vinegar cured or pickled
F140	Trout - smoked, salted, dried, vinegar cured or pickled
F140	Sprats - smoked, salted, dried, vinegar cured or pickled
F140	Sablefish - smoked, salted, dried, vinegar, cured or pickled
F140	Pollock - smoked, salted, dried, vinegar cured or pickled fish
F140	Mudfish - smoked
F140	Turbot (greenland halibut) - smoked, salted, dried or pickled
F140	Hake - smoked, salted, dried, vinegar cured or pickled
F140	Haddock - smoked, salted, dried, vinegar cured or pickled
F140	Alewife - smoked, salted, dried, vinegar cured or pickled
F140	Goldeye - smoked, salted, dried, vinegar cured or pickled
F140	Eel - smoked, salted, dried, vinegar cured or pickled
F140	Cusk - smoked, salted, dried, vinegar cured or pickled
F140	Cod - smoked, salted, dried, vinegar cured or pickled
F140	Anchovies - smoked, salted, dried, vinegar cured or pickled

F140	Herring (kippers) - smoked, salted, dried, vinegar cured or pickled
F140	Salmon - smoked, salted, dried, vinegar cured or pickled
F142	**Salmon - canned**
F143	**Tuna - canned**
F143	Albacore (tuna) - canned
F143	Yellowfin (tuna) - canned
F143	Skipjack or striped-bellied bonito (tuna) - canned
F143	Longfin (tuna) - canned
F143	Bluefin (tuna) - canned
F143	Bonito (tuna) - canned
F146	**Fish - other - canned**
F146	Kippered snacks - canned
F146	Anchovy - canned
F146	Sardines in tomato sauce - canned
F146	Sardines - canned
F146	Pilchard (sardines) - canned
F146	Mexican fish - canned
F146	Mackerel - canned
F146	Gefilte fish - canned
F146	Fish pate (except shellfish) - canned
F146	Fish paste - canned
F146	Finnan haddie - canned fish
F146	Creamed salmon with/without peas - canned
F146	Chicken haddie - canned fish
F146	Herring - canned
F149	**Shrimps and prawns**
F149	Shrimp meat - canned freeze-dried
F149	Shrimp cocktail - frozen
F149	Shrimp and prawn meat - fresh or frozen
F149	Shrimp and prawn meat - canned
F149	Shrimp - frozen cooked
F149	Breaded shrimps - fresh or frozen
F149	Shrimps and prawns in shells - fresh or frozen
F149	Breaded shrimps - pre-cooked - frozen

F151	**Shellfish - other**
F151	Marine products - all other
F151	Scallop meat - fresh or frozen
F151	Lobsters in shell - fresh or frozen
F151	Mussels - fresh
F151	Octopus
F151	Oyster meat - fresh or frozen
F151	Oysters in the shell - fresh
F151	package seafood
F151	Smoked oysters - canned
F151	Quahogs
F151	Scallops in shells - fresh
F151	Sepia
F151	Squid (Atlantic or Pacific)
F151	Smoked mussels - canned
F151	Calamari - shellfish
F151	Lobster spread
F151	Periwinkle (winkle)
F151	Clams in shells - fresh
F151	Clam meat - fresh
F151	Abalone in shell - fresh
F151	Lobster preparations - canned
F151	Clam meat - frozen
F151	Crab meat - canned
F151	Crab meat - fresh or frozen
F151	Crabs in shell - fresh or frozen
F151	Lobster paste - canned
F151	Escargots (snails)
F151	Fruit de mer
F151	Chocos shellfish
F151	Lobster meat - canned
F151	Lobster meat - fresh
F151	Lobster meat - frozen
F151	Cuttlefish (shellfish)
F151	Turtle meat
F151	Caviar substitutes (from roe of other fish, except sturgeon) - canned
F151	Eel liver
F151	Fish roe
F151	Fish tongues
F151	Pompano
F151	Seal meat
F151	Caviar - canned (prepared from the roe of sturgeon)

F156	**Cream (except sour cream)**
F156	Cereal cream (half and half)
F156	Table cream
F156	Whipping cream
F157	**Low-fat milk (1%)**
F158	**Fluid whole milk**
F159	**Low-fat milk (2%)**
F160	**Fluid skim milk**
F160	Shape Lite (TM)
F161	**Specialty milk products**
F161	Lactose reduced milk
F161	Sterilized milk
F161	Acidophilus milk
F161	Lactaid (TM)
F162	**Fresh yogurt (any size)**
F162	Kefir (TM) (organic milk)
F163	**Butter**
F163	Creamery butter
F163	Farm made butter (dairy butter)
F163	Reworked butter
F166	**Cheddar cheese**
F166	Cheddar cheese (mild, medium, old) (except grated)
F166	Cheddar cheese curds
F166	White cheese (cheddar cheese) (except grated)
F166	Lonepine variety pack (cheese) (TM)
F167	**Grated cheese**
F167	Grated cheddar cheese
F167	Grated mozzarella cheese
F167	Grated parmesan cheese
F167	Grated romano cheese
F167	Shredded mozzarella cheese (light)
F168	**Process cheese**
F168	Gruyere process cheese
F168	Spray cheese (aerosol)
F168	Process cheese spread
F168	Process cheese food
F168	Cheese mix
F168	Cheddar based process cheese
F168	Process cheese slices
F168	Velveeta (TM)
F168	Cheese Nibblers (TM)
F168	Cheestrings (TM)
F168	Cheez Whiz (TM)
F168	Cheez Whiz Squeez cheese (TM)
F168	Snackeroo's (TM)

F169	**Cottage cheese (creamed or not creamed)**
F169	Ricotta cheese 5%
F175	**Cheese - other**
F175	Romano cheese (except grated)
F175	Jarlsberg cheese
F175	Limburger cheese
F175	Mozzarella cheese (except grated)
F175	Muenster cheese
F175	Neufchatel cheese
F175	Oka cheese
F175	Parmesan cheese (except grated)
F175	Provolone cheese
F175	Roquefort cheese
F175	Samsoe cheese
F175	Skim milk cheese
F175	Swiss cheese
F175	Trappist cheese
F175	Whey cheese
F175	Havarti cheese
F175	Cheshire cheese
F175	Colby cheese
F175	Anfrom cheese
F175	Blue cheese
F175	Bonbel cheese
F175	Brick cheese
F175	Brie cheese
F175	Cream cheeses
F175	Camembert cheese
F175	Gruyere cheese (except processed)
F175	Danbo cheese
F175	Edam cheese
F175	Elbo cheese
F175	Emmentaler (swiss) cheese
F175	Feta cheese
F175	Ficello cheese
F175	Gorgonzola cheese
F175	Gouda cheese
F175	Boursault cheese (TM)
F175	Philadelphia cream cheese (TM)
F177	**Condensed or evaporated milk**
F177	Condensed skim milk
F177	Condensed whole milk
F177	Evaporated partly skimmed milk
F177	Evaporated skim milk
F177	Evaporated whole milk

F178	**Ice cream and ice milk (500 ml or more portions, except novelties)**
F178	Ice cream and ice milk (less than 500 ml portions, except novelties)
F178	Ice milk - 500 ml or more
F178	Ice cream (less than 500 ml)
F178	Ice milk - less than 500 ml
F179	**Ice cream or ice milk novelties**
F179	Ice cream bars
F179	Ice milk novelties
F179	Ice cream pies
F179	Ice cream novelties
F179	Ice cream cakes
F179	Ice cream cones (containing ice cream)
F179	Revels (TM)
F179	Fudgsicles (TM)
F179	Numaid (TM)
F179	Nutty buddies (TM)
F181	**Frozen yogurt (less than 500 ml) (including novelties)**
F181	Frozen yogurt (500 ml or more)
F186	**Eggs**
F186	Whole eggs - dried
F186	Butter & Egg
F186	Egg Beaters (TM)
F187	**Dairy products - other**
F187	Skim milk powder
F187	Unspecified cheese
F187	Malted milk mix
F187	Whole milk powder
F187	Whip cream - canned
F187	Vegetable dip
F187	Tzatziki (dip made with yogurt and cucumber)
F187	Processed sour cream
F187	Omelette pack
F187	Nacho cheese dip
F187	Butter spread (butter base)
F187	Milk sherbets - frozen (500 ml and over)
F187	Goats milk
F187	Garlic spread
F187	Cheese for fondue
F187	Milkshake mix
F187	Buttermilk powder
F187	Garlic butter
F187	Chip dips - dairy base
F187	Chocolate drink, fluid, milk base

F187	Chocolate malted milk
F187	Dairy spreads with herbs
F187	Devon cream - canned fresh
F187	Drinkable yogurt
F187	Eggnog milk
F187	Buttermilk fluid
F187	Danone cheese/yogurt mixed cup (TM)
F187	Minigo (TM)
F187	Wally Dipper (TM)
F187	Yop (TM)
F192	**Bread**
F192	Raisin bread
F192	Baguettes
F192	Dietary bread
F192	Garlic bread - fresh or frozen
F193	**Unsweetened rolls and buns**
F193	Kaiser rolls
F193	Scones
F193	Cheese buns
F193	Rye buns
F193	Tea biscuits
F193	Pastry shells
F193	Onion buns
F193	Scotch baps
F193	Hamburger buns
F193	English muffins
F193	Dinner buns and rolls
F193	Croissants
F193	Brioches
F193	Bagels
F193	Hot dog rolls
F193	Crumpets

F195	**Crackers and crisp breads**
F195	Cheese crackers
F195	Zwieback
F195	Soup crackers
F195	Soda crackers / saltines
F195	Rye-king
F195	Rusks
F195	Party crackers
F195	Melba toast
F195	Crisp bread
F195	Bread sticks
F195	Croutons
F195	Stoned Wheat Thins (TM)
F195	Ritz (TM)
F195	Wasa (TM)
F195	Vegetable Thins (TM)
F195	Dutch rusks
F195	Bacon bites (TM)
F195	Cabaret (TM)
F195	Bacon Dippers (TM)
F195	Triscuit (TM)
F197	**Cookies and sweet biscuits**
F197	Wafers (biscuits)
F197	Open-faced or coated mallows
F197	Peanut butter cookies
F197	Plain cookies
F197	Pocky sticks
F197	Sandwich-style biscuits
F197	Oatmeal cookies
F197	Sweetened biscuits
F197	Fruit cookies
F197	Shortbread
F197	Graham wafers
F197	Graham wafer crumbs
F197	Fig newtons
F197	Digestives
F197	Coconut cookies
F197	Coated biscuits
F197	Chocolate chip cookies
F197	Bulk purchase of biscuits
F197	Arrowroot biscuits
F197	Graham wafer pie shells
F197	Wagon Wheels (TM)
F197	Oreo Cookie Crumbs (TM)
F197	Oreo cookie pie shells (TM)

F198	**Doughnuts**
F198	Fritters (dessert)
F199	**Yeast-raised sweet goods (including fruit buns)**
F199	Sweet rolls
F199	Butterhorns
F199	Chelsea buns
F199	Cinnamon buns
F199	Coffee cakes
F199	Danish pastries
F199	Easter buns
F199	Hot cross buns
F201	**Dessert pies, cakes, squares and other pastries (except frozen and meat pies)**
F201	Fruit and nut bread
F201	Sweet rice & banana
F201	Strudels
F201	Spanish bar
F201	Queen Elizabeth cake
F201	Rice cake & mung bean
F201	Pumpkin bread
F201	Persians
F201	Napoleons
F201	Nanaimo bars (fresh)
F201	Jam tarts
F201	Turnovers (fruits)
F201	Butter tarts
F201	Baklavas
F201	Banana bread
F201	Beaver Tails
F201	Eclairs
F201	Brownies
F201	Rice cake & pork
F201	Corn bread
F201	Cream pies
F201	Cream slice
F201	Custard pies
F201	Custard slices
F201	Bismarck
F201	Pop Tarts (TM)
F201	Rose Marie Vanilla (TM)
F202	**Muffins**
F202	Bran muffins
F202	Corn meal muffins
F202	Muffins - store packaged fresh

F205	**Bakery products - other**
F205	Rice snacks
F205	Wafer roll
F205	Plum pudding
F205	Poppadums
F205	Poultry stuffing mix
F205	Refrigerated cookie dough
F205	Refrigerated dinner roll dough
F205	Rice paper of starch or flour
F205	Rice sticks
F205	Taco shells
F205	Tortilla shells
F205	Umpia wrapper
F205	Pita bread
F205	Rice cakes
F205	Fruit and nut roll - canned
F205	Pizza shells - frozen
F205	Bread crumbs
F205	Canned cake
F205	Dietary biscuits
F205	Platina
F205	Egg roll shells
F205	Graham (Polish)
F205	Hardtack (ship's biscuits)
F205	Ice cream cones and wafers
F205	Matzos (unleavened bread) and matzo products
F205	Meringues
F205	Oat cakes
F205	Passover bread
F205	Dough and uncooked pastry (incl. frozen)
F211	**Pasta products - canned**
F211	Macaroni and cheese - canned pasta
F211	Vermicelli - canned pasta
F211	Spaghetti with meatballs - canned
F211	Noodle numbers - canned
F211	Spaghetti - canned pasta
F211	Alphabets - canned pasta (TM)
F211	Alpha-getti - canned pasta (TM)
F211	Beef-a-roni (TM)
F211	Scarios (TM) - canned pasta
F211	Zoodles (TM) - canned pasta

F212	**Pasta - fresh or dry**
F212	Pastina
F212	Penne
F212	Rigatoni - fresh or dry
F212	Rotini - fresh or dry
F212	Spaghetti - fresh or dry pasta
F212	Spatzel
F212	Spaghettini - fresh or dry pasta
F212	Pasta shapes (bows, stars, elbows)
F212	Cannelloni - fresh or dry pasta
F212	Pasta - fresh
F212	Vermicelli - fresh or dry
F212	Chinese noodles - fresh or dry pasta
F212	Egg noodles - fresh or frozen
F212	Farfall
F212	Kielke
F212	Lasagne - fresh or dry
F212	Macaroni shells
F212	Manicotti
F212	Udon Noodles (TM)
F212	Barilla (TM)
F215	**Pasta mixes**
F215	Pasta casserole bases
F215	Lasagne dinner mix
F215	Noodles Romanoff - pasta mix
F215	Packaged macaroni dinners
F215	Top Ramer (TM)
F215	Spirals (TM) - pasta mixes
F215	Hamburger Helper (TM) - pasta mixes
F215	Kraft dinner (TM) - pasta mixes
F221	**Rice (including mixes)**
F221	Brown rice
F221	Curried rice mix
F221	Fried rice mix
F221	Instant rice
F221	Parboiled rice
F221	Polished and glazed rice
F221	Rice - pre-cooked
F221	Spanish rice mix
F221	Wild rice
F221	Wild rice mix
F221	Rice-A-Roni (TM)
F221	Minute Rice (TM)

F226	**Flour**
F226	Ontario winter wheat flour (soft white)
F226	Alberta winter wheat flour (hard red)
F226	Sweet rice powder
F226	Rye flour
F226	Potato flour
F226	Oat flour
F226	Mixed cereal flour
F226	Gluten and gluten flour
F226	Durum semolina and flour
F226	Corn flour
F226	Cake flour
F226	Buckwheat flour
F226	Blended flour
F226	Rice flour
F226	Masa Mixta (TM)
F232	**Cereal grains (unmilled or milled) - other**
F232	Natural bran
F232	Uncooked rolled oats
F232	Wheat germ
F232	Uncooked oatmeal
F232	Pearl barley
F232	Malt
F232	Hominy grits
F232	Couscous
F232	Corn meal
F232	Buckwheat meal
F232	Bulgur
F236	**Breakfast cereal (except infant cereal)**
F236	Puffed rice
F236	Wheat flakes (breakfast cereal)
F236	Shredded wheat cereal
F236	Puffed wheat
F236	Corn flakes
F236	Instant oatmeal
F236	Cream of wheat
F236	Instant rolled oats
F236	Bran cereal
F236	Granola
F236	Muffets

F237	**Cake and other flour-based mixes**
F237	Yorkshire pudding mix
F237	Pancake flour mix
F237	Pie crust mix
F237	Pudding cake mixes
F237	Quick bread mixes
F237	Roll mix
F237	Snacking cake
F237	Streusel mix
F237	Dumpling mix
F237	Sponge pudding mixes
F237	Brownies (prepared flour mix)
F237	Muffin mix
F237	Biscuit mix
F237	Macaroon mix
F237	Buckwheat mix
F237	Bundt mix
F237	Cheese cake mix
F237	Cookie mix
F237	Dessert bar mixes
F237	Batter mixes
F238	**Cereal-based snack foods**
F238	Corn sticks
F238	Pretzels
F238	Prepared popcorn (except candied popcorn)
F238	Salted toasted corn
F238	Popping corn
F238	Microwave popcorn
F238	Corn chips
F238	Cheese sticks
F238	Nacho chips
F238	Popcorn and vegetable oil in packages
F238	Nu Vita hob-nobs
F238	Sun Chips (TM)
F238	Old Time Onion Squares (TM)
F238	Doritos (TM)
F238	Crunchies (TM)
F238	CH snacks (TM)
F238	Buttons and Bows (TM)
F238	Bugles (TM)
F238	Bagel Chips (TM)
F238	Pita puffs (TM)
F238	Cheetos Twisties (TM)
F239	**Cereal products - other**
F239	Nuts and Bolts

F243	**Apples - fresh**
F243	Crab apples - fresh
F244	**Bananas and plantains - fresh**
F246	**Grapefruit - fresh**
F247	**Grapes - fresh**
F247	Bulk purchase of grapes
F248	**Lemons and limes - fresh**
F249	**Melons - fresh**
F249	Honeydew melons - fresh
F249	Muskmelons - fresh
F249	Watermelons - fresh
F249	Cantaloupes - fresh
F250	**Oranges and other citrus fruit - fresh**
F250	Ugli fruit - fresh
F250	Bergamots
F250	Citrons - fresh
F250	Clementines - fresh
F250	Kumquats - citrus fruit - fresh
F250	Mandarins - fresh
F250	Minneola
F250	Pomelo
F250	Seville oranges
F250	Tangelos
F250	Tangerines
F251	**Peaches and nectarines - fresh**
F252	**Pears - fresh**
F253	**Plums - fresh**
F253	Greengage plums - fresh
F253	Prune plums - fresh

F256	**Tropical fruit - other - fresh**
F256	Mangoes - tropical fruit - fresh
F256	Quinces - tropical fruit - fresh
F256	Pomegranates - fresh
F256	Pitted dates
F256	Pineapples - fresh
F256	Persimmons - tropical fruit - fresh
F256	Passion fruit - tropical fruit - fresh
F256	Papayas - tropical fruit - fresh
F256	Lichis - tropical fruit - fresh
F256	Calamansi
F256	Kiwi fruit - fresh
F256	Olives - fresh
F256	Breadfruit
F256	Chinese pear
F256	Durian - fresh
F256	Figs
F256	Guavas - tropical fruit - fresh
F256	Jack fruit
F256	Kaki
F256	Avocados - fresh
F258	**Strawberries - fresh**
F262	**Fruit - other - fresh**
F262	Cranberries - fresh
F262	Raspberries - fresh
F262	Pumpkin - fresh
F262	Mixed fruit (including fruit baskets)
F262	Rhubarb - fresh
F262	Cherries - fresh
F262	Blueberries - fresh
F262	Apricots - fresh
F262	Five berry mix - fresh
F262	Gooseberries - fresh
F266	**Fruit - frozen**
F266	Blueberries - frozen
F266	Saba bananas (frozen banana)
F266	Rhubarb - frozen
F266	Raspberries - frozen
F266	Pumpkin - frozen
F266	Pineapples - frozen
F266	Pears - frozen
F266	Cherries - frozen
F266	Apples - frozen
F266	Strawberries - frozen
F266	Peaches - frozen

F272	**Raisins - dried**
F274	**Fruit (except canned) - other - dried, dehydrated or other preserved**
F274	Maraschino cherries in liquid preservative (except canned)
F274	Prunes (dried plums)
F274	Pineapple - dried
F274	Pears - dried
F274	Mesclum mixture
F274	Fruit peel - dried
F274	Fruit mixtures - dried
F274	Fruit bars - dried, dehydrated or preserved fruit (except canned)
F274	Figs - dried
F274	Dragon eye (dried lychee)
F274	Currants (dried grapes)
F274	Crystallized fruit peel (except canned)
F274	Crystallized and glace cherries (except canned)
F274	Citrus rinds - dried
F274	Apples - dried
F274	Candied cherries (except canned)
F274	Peaches - dried
F274	Berries - dried or dehydrated
F274	Bananas - dried or dehydrated
F274	Apricots - dried
F274	Dates - dried
F281	**Apple juice (except concentrated)**
F281	Sweet cider (apple juice)
F282	**Grapefruit juice (except concentrated)**
F283	**Orange juice (except concentrated)**
F286	**Fruit juice (except concentrated) - other**
F286	Pineapple juice (except concentrated)
F286	Unfermented grape juice (except concentrated)
F286	Blended fruit juices (except concentrated)
F286	Pure or natural papaya juice (except concentrated)
F286	Wild berry juices (except concentrated)
F286	Pure or natural citrus fruit juice (except concentrated)
F286	Pure or natural apricot juice (except concentrated)
F286	Prune nectar
F286	Lime juice (except concentrated)
F286	Lemon juice (except concentrated)
F286	Grape nectar - (except concentrated)
F286	Grape juice for wine preparation
F286	Blended orange and grapefruit juice (except concentrated)
F286	Apricot nectar (except concentrated)
F286	Passion fruit juice (except concentrated)
F286	Cranberry juice (except concentrated)
F286	5 Alive juice (TM)

F288	**Concentrated orange juice**
F292	**Concentrated fruit juice - other**
F292	Concentrated blended fruit juice - frozen
F292	Pure or natural citrus fruit juice concentrates - frozen
F292	Pineapple juice concentrates - frozen
F292	Lime juice concentrates - fresh or frozen
F292	Lemon juice concentrates - fresh or frozen
F292	Concentrated grapefruit juice - frozen
F292	Apple juice concentrates - frozen
F292	Grape juice concentrates - fresh or frozen
F292	Tropical Sun (TM)
F295	**Peaches - canned**
F297	**Pineapple - canned**
F298	**Mixed fruit - canned**
F298	Peaches and pears - canned
F298	Fruit cocktail - canned
F298	Fruit salad - canned
F298	Tropical fruit cocktail - canned
F298	Orange and grapefruit pieces - canned
F302	**Fruit - other - canned**
F302	Pears - canned
F302	Strawberries - canned
F302	Raspberries - canned
F302	Pumpkin (except pie filling) - canned
F302	Plums - canned
F302	Maraschino cherries - canned
F302	Mandarin oranges - canned
F302	Loganberries - canned
F302	Lichis - canned
F302	Apple sauce - canned
F302	Figs - canned
F302	Cranberries - canned
F302	Crab apples - canned
F302	Prunes - canned
F302	Cherries - canned
F302	Blueberries - canned
F302	Blackberries - canned
F302	Apricots - canned
F302	Grapefruit - canned
F302	Apple Snax (TM)

F304	**Jam, jelly and other preserves (including marmalade)**
F304	Mint jelly
F304	Collation Pom
F304	Cranberry jelly - canned
F304	Cranberry sauce - canned
F304	Crystallized and glace fruits - canned
F304	Jams and other preserves - canned
F304	Jellies - canned
F304	Marmalades - canned
F305	**Fruit pie fillings - canned**
F305	Lemon pie filling - canned
F305	Mincemeat (mainly fruit) - canned
F305	Pumpkin pie filling - canned
F305	Rhubarb pie filling - canned
F305	Strawberry/rhubarb pie filling - canned
F305	Apple pie filling - canned
F311	**Unshelled nuts (nuts with shells)**
F311	Unshelled or unroasted almonds (nuts with shells)
F311	Unshelled walnuts (nuts with shells)
F311	Unshelled sunflower seeds (nuts with shells)
F311	Unshelled pistachio nuts (nuts with shells)
F311	Unshelled pecans (nuts with shells)
F311	Unshelled peanuts (nuts with shells)
F311	Unshelled or unroasted brazil nuts (nuts with shells)
F311	Unshelled hazelnuts (nuts with shells)
F311	Unshelled filberts (nuts with shells)
F311	Unshelled coconuts (nuts with shells)
F311	Unshelled chestnuts (except horse chestnuts) (nuts with shells)
F311	Unshelled cashew nuts (nuts with shells)
F311	Mixed unshelled nuts (nuts with shells)
F311	Unshelled marrons (nuts with shells)
F311	Unshelled or unroasted butternuts (nuts with shells)
F311	Spitz (TM)

F312	**Shelled peanuts (except salted) (nuts without shells)**
F312	Salted peanuts (shelled) (nuts without shells)
F312	Dry roasted peanuts
F313	**Salted shelled nuts - other (nuts without shells)**
F313	Shelled nuts (except salted) - other (nuts without shells)
F313	Shelled or roasted pecans - salted (nuts without shells)
F313	Slivered nuts - salted (nuts without shells)
F313	Shelled or roasted walnuts - salted (nuts without shells)
F313	Shelled or roasted filberts - salted (nuts without shells)
F313	Shelled or roasted cashew nuts - salted (nuts without shells)
F313	Shelled or roasted brazil nuts - salted (nuts without shells)
F313	Shelled or roasted almonds - salted (nuts without shells)
F313	Roasted chestnuts - salted (nuts without shells)
F313	Mixed shelled nuts - salted (nuts without shells)
F313	Flaked or ground nuts salted (nuts without shells)
F313	Shelled pistachio nuts - salted (nuts without shells)
F313	Coconut meat (including shredded and desiccated) unsalted (nuts without shells)
F313	Shelled or roasted brazil nuts (nuts without shells)
F313	Slivered nuts - unsalted (nuts without shells)
F313	Shelled pistachio nuts (nuts without shells)
F313	Shelled or roasted walnuts (nuts without shells)
F313	Shelled or roasted pecans (nuts without shells)
F313	Shelled or roasted filberts (nuts without shells)
F313	Shelled or roasted cashew nuts (nuts without shells)
F313	Shelled or roasted almonds (nuts without shells)
F313	Shelled hazelnuts (nuts without shells)
F313	Roasted sunflower seeds (deep fried) (nuts without shells)
F313	Roasted chestnuts (nuts without shells)
F313	Mixed shelled nuts (nuts without shells)
F313	Melon, watermelon and pumpkin seeds roasted and salted for food (nuts without shells)
F313	Flaked or ground nuts (nuts without shells)
F313	Sweetened coconut
F313	Macadamian nuts - unsalted (nuts without shells)

F318	**Green or wax beans - fresh**
F319	**Broccoli - fresh**
F321	**Cabbage - fresh**
F322	**Carrots - fresh**
F323	**Cauliflower - fresh**
F324	**Celery - fresh**
F325	**Corn - fresh**
F326	**Cucumbers - fresh**
F326	Gherkins - fresh
F326	Bulk purchase of cucumbers
F327	**Lettuce - fresh**
F327	Boston lettuce
F327	Cos lettuce
F327	Iceberg lettuce
F327	Leaf lettuce
F327	Mixed lettuce/radicchio (musceli)
F327	Romaine lettuce
F328	**Mushrooms - fresh**
F329	**Onions - fresh**
F329	Shallots - fresh
F329	Scallions - fresh
F330	**Peppers - fresh**
F330	Pimentos - fresh
F331	**Potatoes - fresh**
F332	**Radishes - fresh**
F332	Daikon
F333	**Spinach - fresh**
F334	**Tomatoes - fresh**
F334	Bulk purchase of tomatoes
F335	**Turnips and rutabagas**
F335	Rabioles (white turnips)
F335	Swedish turnips - fresh

F344	**Leaf and stalk vegetables - other - fresh**
F344	Rapini - fresh
F344	Fennel - fresh
F344	Fiddleheads - fresh
F344	Jicama
F344	Ka-Lan
F344	Leeks
F344	Marjoram - fresh
F344	Water cress - fresh
F344	Nappa
F344	Parsley - fresh
F344	Sorrel - fresh
F344	Split mung bean - fresh
F344	Sugar cane
F344	Swiss chard - fresh
F344	Endives - fresh
F344	Beet greens - fresh
F344	Asparagus - fresh
F344	Alfalfa sprouts - fresh
F344	Brussels sprouts - fresh
F344	Arugula - Rocket salad
F344	Dill - fresh
F344	Basil - fresh
F344	Bean sprouts - fresh
F344	Chicory - fresh
F344	Chinese cabbage
F344	Choi sam
F344	Cilantro - fresh
F344	Coriander - fresh
F344	Curly cabbage
F344	Bok choy
F344	Artichokes - fresh (except Jerusalem artichokes)
F345	**Seed and gourd vegetables - other - fresh**
F345	Lima beans - fresh
F345	Okra - fresh
F345	Squash - fresh
F345	Vegetable marrows - fresh
F345	Kang Kong
F345	Zucchini - fresh
F345	Eggplant - fresh
F345	Green peas - fresh
F345	China egg plant
F345	Bitter melon
F345	Beinjals - fresh (eggplant)
F345	Gumbo - fresh

F346	**Root vegetables - other - fresh**
F346	Jerusalem artichokes
F346	Water chestnuts - fresh
F346	Taro root
F346	Sweet potatoes and yams - fresh or chilled
F346	Sweet potatoes
F346	Parsnips - fresh
F346	Horseradish - fresh
F346	Addoes
F346	Ginger root - fresh
F346	Salsify - fresh
F346	Garlic - fresh
F346	Elephant garlic
F346	Cassava - fresh
F346	Beets - fresh
F346	Groupings of assorted vegetables for stews/soups
F351	**Corn - frozen**
F352	**Peas - frozen**
F353	**Potato products - frozen**
F353	Cassava (Kinayod)
F353	French fries - frozen
F353	Hash browns - frozen
F353	Julienne potatoes - frozen
F353	Potato patties - frozen
F353	Potato puffs - pre-cooked frozen
F353	Tater gems - frozen
F353	Superfries (TM) - frozen
F353	Beefeater (TM) potatoes - frozen
F353	Dollar (TM) chips - frozen
F363	Vegetables - other - frozen
F363	Squash - frozen
F363	Zucchini - breaded or battered
F363	Spinach - frozen
F363	Onion rings (in batter) - pre-cooked frozen
F363	Mushrooms - breaded or battered
F363	Mixed vegetables - frozen
F363	Lima beans - frozen
F363	Fiddleheads - frozen
F363	Cauliflower - frozen
F363	Carrots - frozen
F363	Brussels sprouts - frozen
F363	Broccoli - frozen
F363	Asparagus - frozen
F363	Green or wax beans - frozen

F366	**Potato products - dried**
F366	Potatoes au gratin - dried (except canned)
F366	Potatoes with sauce mixes
F366	Instant mashed potatoes
F366	Hash brown potatoes - dried
F366	Scalloped potatoes - dried
F367	**Vegetables (except canned) - dried**
F367	Navy beans - (except canned)
F367	White pea beans (except seed) - dried
F367	Split peas - dried
F367	Split mung bean - dried
F367	Lima beans (except seed) - dried
F367	Refried beans - powdered
F367	Yam tuber
F367	Red kidney beans (except seed) - dried
F367	Mung beans (except seed) - dried
F367	Lotus root - dried
F367	Lentils - dried
F367	Chopped onions - dried
F367	Chick peas - dried
F367	Minced garlic - dried
F367	Mushrooms - dried (except canned)
F371	**Green or wax beans - canned**
F372	**Baked beans - canned**
F373	**Beans - other - canned**
F373	Faba beans - canned
F373	Refried beans - canned
F373	Navy beans - canned
F373	Lima beans - canned
F373	Kidney beans - canned
F373	Fava beans - canned
F373	Chick peas - canned
F373	Broad beans - canned
F373	Black eyed bean - canned
F373	Garbanzo beans - canned

F376	**Corn - canned**
F377	**Mushrooms and truffles - canned**
F377	Mushrooms - canned
F377	Mushrooms - pieces and stems - canned
F377	Truffles - canned
F378	**Peas - canned**
F379	**Tomatoes (including paste) - canned**
F379	Tomato paste - canned
F379	Tomato sauce - canned
F379	Stewed/crushed/diced/whole tomatoes - canned
F388	**Vegetables (except infant foods) - other - canned**
F388	Potatoes (except infant foods) - canned
F388	Yams - canned
F388	Water chestnuts - canned
F388	Vine leaves - canned
F388	Sweet potatoes - canned
F388	Squash - canned
F388	Spinach (except infant foods) - canned
F388	Red peppers - canned
F388	Pimentos - canned
F388	Bamboo shoots - canned
F388	Sauerkraut - canned
F388	Asparagus (except infant foods) - canned
F388	Peas and carrots (except infant foods) - canned
F388	Bean sprouts - canned
F388	Beets - canned
F388	Carrots - canned
F388	Green peppers - canned
F388	Macedoine mixed vegetables (except infant foods) - canned
F388	Mixed vegetables (except infant foods) - canned
F388	Okra - canned
F390	**Tomato juice - canned**
F394	**Vegetable juice - other - canned**
F394	Carrot juice - canned
F394	Mixed vegetable juice - canned
F394	Beefamato - canned (TM)
F394	Clamato (TM)
F394	V8 juice (TM)

F396	**Pickles (including olives)**
F396	Pimentos - pickled
F396	Walnuts - pickled
F396	Peppers - pickled
F396	Onions - pickled
F396	Olives in liquid preservative
F396	Olives - canned
F396	Mushrooms - pickled
F396	Mixed pickles
F396	Mango pickles
F396	Bread and butter pickles
F396	Eggs - pickled
F396	Dill pickles
F396	Cocktail onions
F396	Chives - pickled
F396	Chillies - pickled
F396	Capers
F396	Beets - pickled
F396	Gherkins - pickled
F400	**Ketchup**
F400	Catsup (ketchup)
F405	**Other sauces/gravy and sauce mixes**
F405	Sparerib sauce
F405	Spaghetti sauce
F405	Seafood sauce
F405	Spaghetti sauce with meat
F405	Spaghetti sauce with mushrooms
F405	Soya sauce
F405	Steak sauce
F405	Stir fry sauce
F405	Taco sauce
F405	Tartar sauce
F405	Worcestershire sauce
F405	Sauce mixes
F405	Pepper steak mix
F405	Teriyaki sauce
F405	Bar-b-que sauce
F405	Pizza sauce
F405	Oyster sauce
F405	Mushroom sauce
F405	Mint sauce
F405	Meat gravy (except canned) - dried
F405	Honey garlic sauce
F405	Hollandaise sauce
F405	Guacamole

F405	Chili sauce
F405	Bearnaise sauce
F405	Plum sauce
F405	Salsa sauce
F405	Hp Sauce (TM)
F405	Velotine (TM)
F405	A1 Steak Sauce (TM)
F405	Tabasco Sauce (TM)
F405	QH Light Blend (TM)
F406	**Mayonnaise and salad dressings**
F406	Low calorie dressings
F406	Thousand islands dressing
F406	Italian dressing
F406	French dressing
F406	Blue cheese dressing
F408	**Condiments (including vinegar) - other**
F408	Vinegar
F408	Vegetable sandwich spreads
F408	Specialty vinegars - other
F408	Rice wine vinegar
F408	Prepared mustard
F408	Prepared horseradish relish
F408	Prepared horseradish
F408	Pickle relish
F408	Mustard sauce
F408	Horseradish mustard
F408	Chutney relish
F408	Balsamic vinegar
F408	Chow chow relish

F410	**Herbs and spices**
F410	Pepper
F410	Parsley - dried
F410	Paprika
F410	Oregano
F410	Mustard - dried
F410	Pimento - dried
F410	Marjoram - dried
F410	Sesame seeds
F410	Mace and nutmegs
F410	Mixed pickling spices
F410	Rosemary
F410	Saffron
F410	Savoury
F410	Grape cardamoms
F410	Spice mixtures
F410	Spnint leaves
F410	Tarragon
F410	Thyme
F410	Turmeric
F410	Vanilla beans
F410	Sage
F410	Chili pepper
F410	Allspice
F410	Anise seeds
F410	Bay leaves - dried
F410	Caraway seeds
F410	Juniper
F410	Celery seeds
F410	Horseradish root - dried
F410	Chili powder
F410	Cinnamon
F410	Garam masala
F410	Celery powder
F410	Ginger
F410	Citrotin
F410	Fennel - dried
F410	Dill
F410	Curry powder
F410	Cumin
F410	Coriander
F410	Cloves
F410	Goberg Lemon pepper (TM)
F410	Keen's Ground Mustard (TM)

F422	**Sugar**
F422	Maple sugar
F422	Loaf sugar from beet or cane
F422	Icing sugar
F422	Dextrose
F422	Cubed sugar
F422	Brown sugar
F422	Fructose (fruit sugar)
F423	**Syrups and molasses**
F423	Table syrup
F423	Treacle
F423	Sugar syrup
F423	Molasses
F423	Maple syrup
F423	Corn syrup
F423	Cane syrup
F423	Blackstrap molasses
F423	Blackstrap syrup
F423	Waffle syrup
F423	Glucose (unmixed corn syrup)
F427	**Gum**
F427	Chewing gum
F427	Bubble gum
F427	Chiclets (TM)
F427	Trident sugar-free gum (TM)
F428	**Candy bars**
F428	Chocolate bars
F430	**Chocolate confections - other**
F430	Easter eggs (chocolate-covered marshmallow)
F430	Chocolate-coated fruits
F430	Packaged chocolates
F430	Liqueur-filled chocolates
F430	Italian chocolate
F430	Boxed chocolates
F430	Chocolate novelties (Easter, Christmas)
F430	Chocolate hollow goods
F430	Bulk chocolates
F430	Chocolate-covered nuts
F430	Chocolate-covered raisins
F430	Smarties (TM)

F431	**Sugar candy**
F431	Dietetic candy (sugarless)
F431	Tangy taffy
F431	Sugar novelties
F431	Small sugar candy (penny goods)
F431	Mints
F431	Lollipops
F431	Jujubes
F431	Hard drops (candy)
F431	Cream mints (candy)
F431	Christmas candy (including canes)
F431	Caramels (candy)
F431	Candy lozenges
F431	Bonbons (candy)
F431	Jelly beans
F431	Spinners (TM)
F431	Squirmies (TM)
F431	Gummie worms (TM)
F431	Sodalicious (TM)
F431	Satin mix (TM)
F431	Lifesavers (TM)
F431	Gushers (TM)
F431	Ganong chews (TM)
F431	Fruit rollups (TM)
F431	Fruit leather (TM)
F431	Fruit by the Foot (TM)
F431	Frisk (TM)
F431	Cherry blaster
F431	Gummie Bears (TM)

F434	**Sugar confections - other**
F434	Cereal bars
F434	Nougat, not containing chocolate
F434	Yogurt covered raisins
F434	Twists (licorice)
F434	Toffee
F434	Tire d'erable
F434	Sesame seed snaps
F434	Peanut brittle
F434	Yogurt malt candy
F434	Marshmallows
F434	Licorice confectionery
F434	Fudge
F434	Fondant
F434	Candied popcorn
F434	Candied nuts
F434	Popsicles
F434	Granola bars
F434	Nutribar (TM)
F434	Nutri-grain bars (TM)
F434	Sun-ups (TM)
F435	**Sugar preparations - other**
F435	Sugar preparations for drinks
F435	Candied ginger
F435	Soda fountain syrups, toppings and fruits
F435	Marshmallow topping
F435	Edible cake decorations
F435	Chocolate syrup
F435	Cake icing
F435	Dessert topping
F435	Root beer syrups
F435	Soft drink concentrates and syrups
F435	Lemonade syrups
F435	Limeade syrups
F435	Cake mate (TM)

F439	**Roasted or ground coffee**
F440	**Coffee - other**
F440	Specialty coffee
F440	Instant coffee
F440	Camp coffee
F440	De-caffeinated coffee
F442	**Tea (including herbal)**
F442	Tea extracts, essences and preparations
F442	Black tea in tea bags
F442	Thermo tea
F442	Tea substitutes
F442	Green tea
F442	Black tea
F442	Instant iced tea
F442	Red Zinger (herbal tea) (TM)
F446	**Margarine**
F446	Butter spreads (margarine base)
F447	**Shortening**
F448	**Lard**
F448	Leaf lard
F448	Tenderflake (TM)
F449	**Cooking/salad oil**
F449	Peanut oil
F449	Safflower oil
F449	Sesame oil
F449	Sunflower oil
F449	Corn oil
F449	Canola oil
F449	Blended vegetable oils
F449	Soya oil
F449	Olive oil
F449	Pam (TM)

F466	**Soup - chilled, frozen or canned**
F466	Cheddar cheese soup - canned
F466	Won ton soup - canned
F466	Turtle soup - canned
F466	Seafood chowders - canned
F466	Fish chowder mix
F466	Cream soups
F466	Consomme/broth - canned
F466	Chowder mix
F466	Borsch (soup) - canned
F466	Clam chowder - canned
F466	Chunky soups (TM) - canned
F467	**Soup - dried**
F467	Soup powders
F467	Cup-a-noodles (TM)
F467	Cup-a-soup (TM)
F467	Ichiban (TM)
F467	Instant snack in a cup (TM)
F467	Souptime (TM)
F467	Beef in Mug
F469	**Infant or junior foods - canned**
F469	Infant foods, dairy produce
F469	Infant vegetables - canned
F469	Infant soups and dinners - canned
F469	Infant meats - canned
F469	Infant fruit juice - canned
F469	Infant fruits, puddings and custards - canned
F472	**Infant cereals and biscuits**
F472	Teething biscuits
F472	Farley's baby biscuits (TM)
F472	Pablum (TM)
F475	**Infant formula**
F475	Formula milk
F475	Good Start (TM)
F475	Isomil (TM)
F475	Pediasure (TM)
F475	Prosobee (TM)
F475	Similac (TM)
F475	Enfalac (TM)

F477	**Dinners - pre-cooked frozen**
F477	Dinners, principally of meat - pre-cooked frozen
F477	Vegetarian dinners - pre-cooked frozen
F477	Tortellini dinners - pre-cooked frozen
F477	TV dinners - pre-cooked frozen
F477	Shellfish dinners - pre-cooked frozen
F477	Fish with vegetables and sauces - pre-cooked frozen
F477	Entrees - precooked - frozen
F477	Chinese food dinners - pre-cooked frozen
F477	Fish and chips - pre-cooked frozen
F480	**Dessert pies, cakes, squares and other pastries - frozen**
F480	Nanaimo bars (frozen)
F480	French toast - frozen
F480	Chocolate eclairs - frozen
F480	Cream pies - pre-cooked frozen
F480	Waffles - frozen
F480	Eggo (TM)
F484	**Meat or poultry pies - frozen**
F484	Sausage rolls - pre-cooked frozen
F484	Ron Dine Italien (TM)
F490	**Other prepared food - pre-cooked frozen**
F490	Pogo
F490	Pork riblets - pre-cooked frozen
F490	Quiche - pre-cooked frozen
F490	Ravioli - precooked - frozen
F490	Rice preparations - pre-cooked frozen
F490	Seafood casseroles - pre-cooked frozen
F490	Smoked meatballs - frozen
F490	Souvlaki - pre-cooked frozen
F490	Spring rolls - pre-cooked frozen
F490	Tortellini - pre-cooked frozen
F490	Burritos - pre-cooked frozen
F490	Vegetable preparations - pre-cooked frozen
F490	Welsh rarebit - pre-cooked frozen
F490	Pizza pops
F490	Submarine sandwiches - frozen
F490	Corned beef hash - pre-cooked frozen
F490	Cabbage rolls - pre-cooked frozen
F490	Cheeseburgers - pre-cooked frozen
F490	Chicken nuggets - pre-cooked frozen
F490	Cauliflower with cheese sauce - pre-cooked frozen
F490	Chinese food dishes - pre-cooked frozen
F490	Pizza pies - pre-cooked frozen
F490	Egg-rolls - pre-cooked frozen
F490	Fish cakes - pre-cooked frozen

F490	Knishes - precooked - frozen
F490	Lasagne - pre-cooked frozen
F490	Macaroni and cheese - pre-cooked frozen
F490	Perogies - pre-cooked frozen
F490	Chicken wings - pre-cooked frozen
F490	Pizza pockets (TM)
F490	Capio double cheese (TM)
F491	**Materials for food preparation**
F491	Gelatin
F491	Yogurt starter
F491	Yeast
F491	Unsweetened cooking chocolate, in blocks and cakes
F491	Textured soy protein
F491	Tapioca (including starch)
F491	Synthetic chocolate
F491	Sweetened chocolate in blocks, cakes, crumbs or granules
F491	Sesame powder
F491	Rice starch
F491	Prepared rennet
F491	Potato starch
F491	Pectin
F491	Grated soya
F491	Cream of tartar
F491	Corn starch
F491	Coconut milk
F491	Coconut cream
F491	Cocoa or chocolate powder
F491	Chocolate chips
F491	Carob chips and powder
F491	Beef suet
F491	Baking soda
F491	Baking powder
F491	Artificial sweeteners
F491	Arrowroot - dried
F491	No-gr-colour
F491	Aspartame (TM)
F491	Certo (TM)

F497	**Honey**
F498	**Peanut butter**
F499	**Dairy product substitutes**
F499	Cream substitutes
F499	Milk substitutes
F499	Rice drink
F499	Soya bean milk
F499	Whipped cream substitutes
F499	Reddi-wip (TM)
F499	Coffee Rich (TM)
F499	Coffee-mate (TM)
F499	Cool Whip (TM)
F499	Dream Whip (TM)
F499	Nutrifil (TM)
F500	**Flavouring extracts and essences**
F500	Liquid non-alcoholic cocktail mixes
F500	Almond extract
F500	Vanilla extract
F501	**Flavouring powders and crystals**
F501	Fruit-flavoured powders
F501	Powdered cocktail mixes
F501	Electrolyte replacement powders (including Gatorade (TM))
F501	Gatorade (TM) - powdered
F501	Kool-aid (TM)
F501	Quench (TM)
F501	Tang (TM)
F502	**Food seasonings (except spices, but including table salt)**
F502	Monosodium glutamate (seasoning)
F502	Onion powder
F502	Vietnamese soup
F502	Table salt
F502	Seasoning salt
F502	Onion salt
F502	Celery salt
F502	Gravy improver
F502	Salt substitute
F502	Garlic powder
F502	Garlic and onion salt seasonings
F502	Dry bouillon extracts, (except canned)
F502	Meat improver (food seasoning)
F502	Shake 'n bake (TM)
F502	Taco Joe seasoning (TM)
F502	Oxo cubes (TM)
F502	Mrs. Dash (TM)
F502	Insta bake

F502	Bovril in liquid form (TM) - canned
F502	Chicken Bouquet
F502	Kitchen Bouquet (TM)
F497	**Honey**
F504	**Prepared dessert powders**
F504	Custard powders
F504	Lemon pie fillings
F504	Butterscotch pie fillings
F505	**Potato-based snack foods**
F505	Julienne potatoes - dried
F505	Prawn chips
F505	Rippled potato chips
F505	Shoestring potatoes
F506	**Food drink powders**
F506	Dietary food drink preparations
F506	Chocolate food drink powders
F506	Cereal grain drink powders
F506	Hot chocolate powders
F506	Instant breakfast (TM)
F506	Ovaltine (TM)
F506	Postum (TM)
F506	Quik (TM)
F507	**Puddings and custards - canned**
F507	Rice pudding - canned
F507	Tapioca puddings - canned
F507	Gelatin-based puddings - canned
F507	Custard puddings - canned
F507	Coco-jel
F507	Chocolate puddings - canned
F507	Caramel puddings - canned
F507	Cornstarch puddings - canned
F518	**Sandwiches and hot food preparation**
F518	Fresh or 'deli' salads
F518	Prepared or 'deli' foods (fresh or canned) - other
F518	Other spreads, pastes and butters (n.e.s.)
F518	All other food preparations (n.e.s.)
F518	Hot egg rolls
F518	Sandwiches (incl. submarines)
F518	Potato wedges
F518	Party tray of sandwiches
F518	Hot quiches
F518	Hot pizza
F518	Hot fried rice
F518	Hot chow mein
F518	Hot chop suey
F518	Hot chile con carne

F518	Hot cabbage rolls
F518	Hot pasta dishes
F518	Tabouli
F518	Vegetable salad
F518	Stew pack
F518	Sauerkraut (except canned)
F518	Salad mix - fresh
F518	Macaroni salad
F518	Fruit salad - fresh
F518	Cole slaw in package
F518	Caesar salad mix - fresh
F518	Bean salad
F518	Potato salad
F518	Salmon pate - fresh
F518	Fried bean ball
F518	Fried rice (prepared) - fresh or canned (except hot)
F518	Hats-n-hams
F518	Kishke - fresh
F518	Knishes - fresh
F518	Pakoras
F518	Pasta and sauces - fresh
F518	Perogies - fresh or canned
F518	Quiches (except pre-cooked frozen)
F518	Pizza - fresh (except hot)
F518	Egg rolls - fresh
F518	Pasta dishes - prepared (except frozen or canned)
F518	Baked beans, fresh (except hot)
F518	Dried dinners
F518	Basket Snack
F518	Cabbage rolls - canned
F518	Cabbage rolls - fresh
F518	Canacella
F518	Dehydrated dinners
F518	Chili con carne - canned
F518	Chili con carne (except hot)
F518	Chop suey - fresh or canned
F518	Salmon mousse - fresh
F518	Chow mein - fresh or canned
F518	Carne Assaba
F518	Lemon cheese
F518	Hazelnut butter
F518	Tahini
F518	Sesame spread
F518	Red bean paste
F518	Peanut butter and jelly
F518	Nut butters (except peanut)

F518	Maple butter
F518	Almond paste
F518	Hummus
F518	Lemon butter
F518	Halvah (sesame seed spread)
F518	Chestnut puree
F518	Cashew butter
F518	Caramel spread
F518	Apple butter
F518	Oven melts
F518	Bean thread noodles
F518	Tofu hot dogs
F518	Tofu
F518	Tempeh
F518	Stir fry vegetable mix - fresh
F518	Roasted hot green peas
F518	Red bean bar
F518	Potato toppers
F518	Pizza mix
F518	Pancake batter - frozen
F518	Tofu burgers
F518	Chicory (coffee substitute)
F518	Nacho cheese mix
F518	Burrito kit
F518	California mix - excluding frozen
F518	Cheese melts
F518	Dietary food powders
F518	Dulse
F518	Food colourings
F518	Fruit and nut mixtures
F518	Gravy mixes
F518	Mountain mix
F518	Cheese & crackers, packaged together
F518	Magic pantry entrees (except pasta) (TM)
F518	Magic pantry cabbage rolls (TM)
F518	Major Gourmet (TM)
F518	Marmite (TM)
F518	Nutella (TM)
F518	Boost liquid (TM)
F518	Tofuti (TM)
F518	Taco trio (TM)
F518	Snack shack
F518	Luncheables (TM)
F518	Juicy Gels (TM)
F518	Bacon Bits (TM)
F518	Kikkoman mix (TM)

F521	**Carbonated beverages**
F521	Soda water
F521	Tonic water
F521	Root beer
F521	Low-calorie carbonated beverages
F521	Cola beverage
F521	Collosal cooler (TM)
F521	Big gulp (TM)
F522	**Fruit drinks**
F522	Squashes (beverage)
F522	Tropical fruit drink
F522	Orange cordial (non-alcoholic)
F522	Saloa
F522	Orange drink
F522	Lime cordial (non-alcoholic)
F522	Lemonade (including pink lemonade)
F522	Lemonade - frozen
F522	Fruit concentrates - frozen
F522	Apple drink
F522	Limeade - frozen
F522	Honeydew (TM) - frozen
F522	Ribena (TM)
F522	Gatorade (TM) fruit drink
F522	Slurpee (TM)
F529	**Non-alcoholic beverages - other**
F529	Non-alcoholic beverages (taxable group) - other
F529	Mineral waters, natural and artificial, carbonated or still
F529	Non-alcoholic beer and wine (.5% or less alcohol)
F529	Liquid iced tea
F529	Cafe lib hot beverage
F529	Lemon barley water
F529	Liquid coffee (hot or iced)
F529	Nantan water (TM)