Vol. 3 No. 2, pp. 145–215 December 2016

Canadian Food Studies La Revue canadienne des études sur l'alimentation

Review Article

Making better use of what we have: Strategies to minimize food waste and resource inefficiency in Canada

Rod MacRae[a], Anne Siu[b], Marlee Kohn[b], Moira Matsubuchi-Shaw[b], Doug McCallum[b], Tania Hernández Cervantes[c], and Danielle Perreault[b]

[a]Associate professor, Faculty of Environmental Studies, York University
rmacrae@ican.net
[b]Masters graduates, Faculty of Environmental Studies, York University
[c]PhD candidate of the Faculty of Environmental Studies, York University

Abstract

We examined the problems of and solutions to food waste through the main three frames of social science research on food waste: political economy; the *cultural turn* (the cultures, ideologies and politics of food and consumption); and political ecology. In the course of our collective research on food waste, we analyzed dozens of government and company documents, interviewed over 35 employees of food chain firms and organizations, including 9 middle to senior managers in food retail, and 2 farmers. One co-author, as part of this and affiliated work (McCallum, Campbell & MacRae, 2014), toured distribution facilities and stores of a major Canadian food retailer, had access to the Company's head office staff, held group and one-on-one interviews with staff in a variety of capacities, and was granted access to confidential corporate reports. Another co-author volunteered with a food recovery organization and spoke with their operational staff. Our method to identify solutions is described in more detail below, but essentially we follow a normative approach as broadly outlined by MacRae and Winfield (2016).

Our focus in this paper is on changes to policies, programmes and legislation/regulation at the level of the state. Such interventions are clearly only a piece of a wide ranging set of initiatives to be undertaken by numerous actors – from food chain firms to individual eaters – but our reading is that more attention has recently been paid to private firm than regulatory changes. We hope to redress this to some degree in this article.

DOI: 10.15353/cfs-rcea.v3i2.143
ISSN: 2292-3071

Key words: food waste, Canada, waste management hierarchies, energy inefficiency

Table of contents

Introduction

In this paper, we proposed solutions to Canada's food waste problem. Since the early days of the Food and Agriculture Organization (FAO), global pressure has been exerted on the food system to increase production. This has conveniently dovetailed with capitalist growth expectations and complied with an international agriculture research agenda, most famously exposited by the work surrounding the Green Revolution. But a significant consequence of this drive to increase output is that much of it is wasted. As such, food waste is the Achilles Heel of the modern food system, revealing many of its structural weaknesses. Contrary to the food system's efficiency rhetoric, it is actually highly inefficient from the perspective of resources consumed, pollution (including GHG emissions) and food insecurity.

In earlier efforts to govern global food, such inefficiencies were on the radar. Parfitt et al. (2010) outline how post-harvest losses, a key element of the waste story, were originally a big part of the FAO mandate. Despite this early preoccupation, almost no research was conducted on reducing widespread post-harvest losses in the 1990s. The FAO had only one small office addressing post-harvest losses, miniscule compared to the institutional resources for yield improvement (Smil, 2004). Only recently has the FAO recaptured an interest in such matters, having recognized that while one-third of food is wasted or lost, 870 million people experience malnutrition and hunger (Gustavsson, Cederberg, Sonesson, van Otterdijk, & Meybeck, 2011). The 2008 food price shocks also contributed to renewed focus on food waste (Evans, Campbell, & Murcott, 2013).

Although no full accounting of the implications for production have been conducted, Smil (2004) roughly calculated that eliminating staple grain post-harvest losses would save enough food to almost meet the caloric needs of the population of India. Consumers in North America and Europe waste almost as much food each year (222 million tonnes) as the entire net food production of sub-Saharan Africa (230 million tonnes) (United Nations Environment Programme, 2013). Abdulla, Martin, Gooch, and Jovel (2013), examining food waste in Canada, concluded that three adults waste enough in a month to feed a fourth adult. This paper takes as a viable premise that significant state interventions to prevent food waste are warranted by the need to increase food availability, decrease pressures to increase yields, and reduce pollution and resource consumption.

Food waste[1] is a broad term requiring some disaggregation (which we provide below). Direct food waste is only one dimension of the resource waste that characterizes the Canadian food system. Essentially, food waste includes any edible food that is not consumed by humans, and human inedible foods that are not used as animal feed or in industrial processes and composting. Such waste also squanders the resources used to produce, process, transport, store and prepare the food. For example, "one calorie of food saved can result in a sevenfold reduction in the energy use across its lifecycle" (Gooch, Felfel, & Marenick, 2010, p. 91). There are also inefficiencies in the food system, augmenting the waste of the resources on which food production and distribution depends. As we discuss in this paper, land is used inefficiently, energy input / output ratios regarding food production vs consumption are poor, animal feeding regimes compete with human edible foods, cooling and heating systems are energy inefficient, and food is consumed in excess of biological requirements (luxus consumption), leading to health problems that individuals and the state pay for in lost productivity and health care expenditures.

While there has been some recent progress reducing direct food waste, often undertaken by private firms (see Uzea, Gooch, & Sparling, 2014 for Canadian examples), no effective initiatives have been put in place that reduce overproduction and overconsumption (Smil, 2004). Unfortunately, much of what has recently been implemented is misdirected or ineffective given

[1] Some analysts distinguish food loss from food waste. In this categorization, food loss refers to a decrease in food quantity or quality of edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. It occurs during the production, post-harvest and processing stages in the food supply chain. Food waste, on the other hand, refers to a subset of food loss that occurs specifically at later stages in the food supply chain, primarily retail and final consumption (Parfitt et al., 2010). However, we do not employ this distinction as it implies that the forces creating food loss are largely beyond our control which is inaccurate (Gille, 2013). We elaborate on this below.

the scale of the problem, a theme we return to later in the paper. This situation exists despite the general recognition that food waste creates negative economic, environmental, and social impacts. The straight economic value of wasted food globally and in Canada represents an annual loss of $750 billion and $31 billion per year[2], respectively (Gooch et al., 2010; Gooch and Felfel, 2014; Gustavsson et al., 2011), but Gooch and Felfel (2014) estimated that the embedded value of Canadian food waste is actually around $107 billion / year because of all the other inputs wasted. Food that is wasted globally is responsible for the release of 3.3 billion tonnes of greenhouse gases into the atmosphere and a global water loss of 675 trillion litres per year (Miller, 2012). In the U.S. alone, the energy contained in wasted food represents approximately two percent of national annual energy consumption (Cuellar & Webber, 2010). Additionally, 1.4 billion hectares of land, or 28% of the world's agricultural area, is used annually to produce food that is wasted (FAO, 2013). There is also recognition of the significant social implications of food waste.

> On 19 January 2012, the European Parliament passed a resolution to tackle food waste and called on the European Commission (EC) to halve current volumes of food waste by 2025 (EC estimates suggest 90 million tonnes are produced annually in the EU). Significantly, in the discussions surrounding these movements the emphasis is on the perversity of wasting food when more than 70 million people in the EU live below the poverty line and 16 million depend on food aid to stave off malnutrition. Here, therefore, we see food waste tied intimately to food poverty. (Evans et al., 2013, p. 18)

Although there is significant imprecision in food waste estimates, by any measure they are enormous and shocking[3]. The most frequently cited study, the FAO's Global Food Losses and Food Waste, estimates that roughly one-third, or 1.3 billion tons per year, of edible parts of food produced for human consumption are wasted globally (Gustavsson et al., 2011). Research to date mostly focuses on avoidable (e.g., bruised fruits, leftovers), rather than unavoidable (e.g., bone, fruit pits) food waste (Gooch et al., 2010), so by the approach taken here, the estimates would be even higher. Indeed, total food waste may be as high as 50% of everything that starts out on a farm, with the U.S. being one country where levels may be this high (Stuart, 2009).

[2] Gooch et al. (2010, p. 2) noted that the quantifiable amount of food waste represents "terminal food waste". Gooch & Felfel's revised estimates (2014) were based on new data on waste in sectors not previously accounted for, particularly seafood capture to processing, institutions and international catering.

[3] A range of methodological approaches has been used to examine food waste, including: archaeological excavations of landfills (Harrison, Rathje, & Huges, 1975; Rathje & Murphy, 1992); applying loss assumptions to national estimates of food supplies (Economic Research Service, 2011; Buzby & Hyman, 2012); household waste composition studies (WRAP U.K., 2011); structured interviews, and many others. The varieties of methodological approaches combined with differing interpretations of food waste conflate estimates across countries and make identifying trends more challenging. To date, the majority of food waste research is conducted in industrialized countries and tends to explore the changing roles and preferences of retailers and consumers (Griffin, Sobal, & Lyson, 2009).

Patterns of food waste differ between developing countries and industrialized countries. Higher incidences of production, distribution and storage losses are characteristic of developing countries, whereas industrialized countries generate much higher levels of food waste at the retail and consumer ends of the supply chain (Parfitt, Barthel, & Macnaughton, 2010).

Our method to identify solutions is described in more detail below, but essentially we follow a normative approach as broadly outlined by MacRae and Winfield (2016). Consistent with that approach, the primary analytical lenses are the main three frames of social science research on food waste: political economy; the ‘cultural turn’ (the cultures, ideologies and politics of food and consumption); and what some call post-humanism (food as “lively stuff” with many non-human actors) (Alexander, Gregson, & Gille, 2013) and others describe as political ecology. We filtered data from primary interviews and secondary sources through these lenses to identify problems and solutions. In the course of our collective research on food waste, we interviewed over 35 employees of food chain firms and organizations, including 10 middle to senior managers in food retail, and 2 farmers (for details, see Kohn, 2011; Siu, 2015; Perreault, 2016). One co-author, as part of this and affiliated work (see McCallum et al., 2014), toured distribution facilities and stores of a major Canadian retailer, had access to the Company’s head office staff, held group and one-on-one interviews with staff in a variety of capacities, and was granted access to confidential corporate reports. Another co-author volunteered with a food recovery organization and spoke with their operational staff. Operational frameworks that helped us assess the merits of different food waste reduction strategies are provided in the Solutions section of the paper.

Our focus is on comprehensive and integrated changes to policies, programmes and legislation/regulation at the level of the state. Such interventions are clearly only a piece of a wide ranging set of initiatives to be undertaken by numerous actors – from food chain firms to individual eaters – but our reading is that more attention has recently been paid to private firm than regulatory changes[4]. We hope to redress this to some degree in this article with a focus on Canada. Since much of the regulatory authority for food waste lies at the provincial and municipal levels, we present Ontario as an example of the changes required across all three levels of governance. In identifying solutions, we draw on examples from other jurisdictions where measures to counter food waste are more advanced, and where appropriate, attempt to adapt them to the Canadian context. We employ a non-traditional structure in presenting our analysis, with data from document reviews and interviews interwoven in our narrative of food system inefficiencies, causal forces, and solutions. In attempting to cover the vast array of issues connected to food waste, we recognize that our analysis is cursory in places and at times uneven, but the absence of a comprehensive and joined up discussion is the motivation for this effort.

[4] For example, the work of WRAP in the UK focuses particularly on the private sector, although the organization does receive government funding.

General data on food waste in Canada

Data help identify strategic interventions, but only a few national studies examine food waste. According to Statistics Canada (2009), about 38%, or 183 kg per person, of the solid food available for retail sale was wasted in 2007. Food losses from retail to household amounted to about 6 million tonnes of food waste (Statistics Canada, 2009:39). The number of calories available per person in 2007 was 3,384 kilocalories; however, only 71% of the calories purchased were consumed, leaving 29% of the calories produced to go to waste (Statistics Canada, 2009:40). The Gooch et al. (2010) study has provided the most commonly referred to estimate of food waste within Canada's agri-food sector. They concluded that approximately 40% of food produced in Canada is not consumed, representing a lost value of $27 billion annually, later revised to $31 billion (Gooch and Felfel, 2014). With around $48.7 billion in sales of agricultural products in 2009, this means that 55% of food is wasted from farm to fork, as measured against sales (Gooch et al., 2010:16).

Working from the Gooch et al. (2010) report[5], Abdulla et al. (2013) identified waste as a percentage of food available for consumption across a 49-year period for different food categories (see Table 1). This included both edible and inedible waste, but is believed to be a conservative estimate because it is impossible to account for all farm, distribution and processing waste.

Table 1: Average % food waste of available food for consumption, 1961 to 2009 (adapted from Abdulla et al., 2013)

Food category	% food waste of available food for consumption
Total fresh fruit	46.19
Total fruit	66.93
Total fresh vegetable	49.91
Total vegetable	42.66
Total dairy products	27.57
Eggs	20.94
Red meat, boneless weight	39.73
Poultry, boneless weight	42.74
Total fish (1988 to 2009)	31.21
Total oil and fats	29.18
Total cereal products	30.00
Total pulses and nuts	15.40
Total sugars and syrups	28.80
Total waste per person per year	44.11

[5] Note that the 2014 update did not substantially change percentages.

From their analysis, 44% of food available for consumption is wasted / person / year, with fruits, vegetables and poultry the most wasted and pulses and nuts the least.

A few regional studies have been undertaken. For example, Parizeau, von Massow, and Martin (2015) found 20% higher levels in a community in Guelph, Ontario than the Statistics Canada study, though the reasons for the higher results are not obvious. Peel Region in Ontario found, in recent curbside audits, that 40% of household food waste was avoidable, with 53% coming from leftovers that could have been eaten, and 47% from untouched food (Peel Region, 2016). A 2014 Metro Vancouver study found that the typical resident purchases too much food and a significant amount goes bad before it can be consumed. Of the avoidable and edible portions, Metro Vancouver wastes 30,000 eggs, 70,000 cups of milk, and 80,000 potatoes every day (Metro Vancouver, n.d.). Many local firms, institutions and facilities have also carried out food waste audits and interventions that we do not report on here.

A brief overview of major forces contributing to food waste

Of the available information, studies on the industrial world unanimously conclude that the largest and second-largest contributors to food waste are consumers and retailers, respectively (Griffin et al., 2009; Gooch et al., 2010; Hodges, Buzby, & Bennett, 2011; Waste and Resources Action Programme U.K., 2011). But such high levels of waste in the industrial world are a relatively recent phenomenon[6]. Parfitt et al. (2010), for example, cite studies on the changes at the U.K. household level, from one to three percent pre-World War II to 25% of current purchases (by weight). Abdulla et al. (2013) concluded that total food waste per capita in Canada increased 40% from 1961 to 2009, which outpaced increases in food availability over the same period. The United Nations Environment Program (2013) concluded that if current rates of food waste continue, by 2050 the world would need 60% more calories than in 2006. Reducing waste by 50% would reduce calorie demand by 20%.

A range of explanations for this type of shift - cultural, political, structural and logistical - have been put forward and we briefly review them here and return to some of these themes when putting forward our proposals for change. Gidwani and Reddy (2011) argue that early British notions of liberalism (and property) were entirely connected to discourses of the time about waste. The British political philosopher John Locke, whose ideas underpin much of political liberalism, positioned the commons as waste. "The theme of nature as bountiful yet wasteful, unless properly harnessed by application of human labor, is a powerful undercurrent in Locke's theory" (p. 1633). Put another way, Nature was profligate so it needed to be controlled. But, given the period's lack of ecological literacy, the controls imposed were entirely unecological in their design. Consequently, they actually generated more and different kinds of waste since waste, as humans have constructed it, does not exist in natural systems.

[6] Of course, waste in pre-industrial periods would have a different character than the current profile.

The current waste problem is in part the wider story of rural-urban antagonism within capitalism (Foster & Magdoff, 1998, Foster, 1999; Friedmann, 2000; Moore 2000, 2011; Clark & York, 2008; Schneider & McMichael, 2010). Marx's theory of metabolic rift explains such antagonism as the separation of social production from its natural biological base, tangibly seen in the separation of production from consumption and the marked division of labour between town and country (Foster & Magdoff, 1998; Friedmann, 2000; Moore, 2000). The metabolic rift framework helps explain the link between problems of soil infertility and environmental degradation and increasingly long-distance global agricultural trade (Schneider & McMichael, 2010).

In Marx's conception, the mechanism of the metabolic rift is the movement of soil nutrients—in the form of grain or other fruits of the land—to towns, where they end up in urban sewage and in the environment as human organic waste (or "humanure"), which should, but typically does not, go back to re-fertilize the land (Foster & Magdoff, 1998, Foster, 1999; Schneider & McMichael, 2010). When people are removed from the land (e.g. migrate to the cities), the "humanure" goes away too, thus breaking the human-nature-metabolic cycle. The urban "Sanitation Revolution", while markedly improving public health, also cemented the separation of humanure from production (Ashley, Cordell, & Mavinic, 2011). Marx focused only on soil as matter, ignoring that soil is indeed a living organism, with health and fertility dependent on a complex soil food web and metabolic reactions between living and non-living components (Schneider & McMichael, 2010). However, our more current understanding of soil reinforces Marx's basic concept.

Friedmann (2000), elaborating on some of her earlier food regime work (Friedmann & McMichael, 1989), shows how the mobility of capital, labour and global outsourcing, resulting from world markets, disrupts the material cycles of local ecosystems (including food nutrient cycles). She highlights that during the nineteenth century, the transformation of local ecologies was not only caused by the trade of food commodities, but also by the arrival of new settlers. New settlers bring cultural diets and farming practices which, once they interact with species invasions and global trade, amplify the vicious circle of dependence on export-oriented agricultural models. This socio-cultural dimension enhances the disruption of local agro-ecosystems linked with global trade and together these phenomena deepen the metabolic rift.

During the second food regime[7] (Friedmann & McMichael, 1989), governments heavily subsidized production with little attention to who would consume the outputs. This triggered another wave of subsidy interventions to find customers for the increased production. Such interventions were consistent with conceptions of a golden era of agricultural science and technology development. They contributed to the era of cheap and excess food on a global scale

[7] To this point, three regimes have been documented. The first had its stable period from 1870 to 1917, the second one, between1947 and 1973, and a third one has supposedly been running since the late 1980s. The characteristics and nature of the third food regime have been the subject of a large, still ongoing, debate (McMichael, 2005; Friedmann, 2005, 2009; Burch & Lawrence, 2009; Campbell, 2009; Holt-Gimenez & Shattuck, 2011).

(though not necessarily within every locality). All of this became elements of what we now know as the modern industrial food system[8], which was consolidated during this second food regime.

Relatively low food prices (compared to earlier historical periods) are also thought to be an important cause of food waste (Rutten, 2013). Particularly for consumers, the relatively low cost of food may prevent taking action. Scarcity, and the associated high cost of wasting food, either in dollar or human resource terms, has historically been a prime force for waste minimization. Now, for agri-food producers and suppliers, it may be better to allow for some food losses at a relatively low cost, rather than take measures to combat it for a seemingly relatively high cost and low returns (Prasada, Bredahl, & Wigle, 2010). The low price of food is partly a product of surplus, but also a product of cost externalization. Neither producers nor consumers are paying the real price, as consequences are externalized to health care and environmental degradation (cf. Tegtmeier & Duffy, 2004). Certainly, one externalized cost is food waste disposal itself, that the fees charged are so low relative to the impacts on the environment and the lost opportunities for use. Government subsidies to energy and waste management contribute to food cost externalization because they appear to make food cheaper.

Coming back to the food regime discussion above, a large body of literature focuses on the growing power held by a limited number of agri-food manufacturers and supermarket chains throughout the global food system. Some scholars have identified this phenomenon as an emerging third food regime, the corporate food regime (Burch & Lawrence, 2009; McMichael, 2009; Holt-Giminez & Shattuck, 2011). Due to their exceptional buying power, food retailers now strongly influence other actors along the food supply chain, which may further affect the generation of food waste (Richards, Bjørkhaug, Lawrence, & Hickman, 2013). Such retailer practices include unnecessary inventory, excessive transportation, lack of coordination along the chain, and high quality standards (Gooch et al., 2010; ERS, 2011; Mena, Adenso-Diaz, & Yurt, 2011). Quality standards can readily be an instrument of economic power as retailers will change them depending on levels of production (Gille, 2013). They can also be used to shift risk to those with less economic power, typically farmers and small suppliers (cf. Campbell, 2002). Both Stuart (2009) and Bloom (2011) identify perverse incentives in the system that result from these power relations, for example, that retailers do not necessarily plan their orders well as, in many cases, produce remaining on shelves is returned unpaid to the producer.

These relations permit supermarkets and general merchandisers selling food to not only waste food at their stores and distribution centres (DCs), but also cause food waste upstream in the supply chain and downstream among consumers. Competitive relations create a lack of coordination among the different actors in the food supply chain and disconnects between the chain and consumers. Manufacturers waste food because of their agreements with retail chains, often overproducing to fulfil retailer demands. Farmers waste food in an effort to provide retailers all year long with the highest cosmetic standards, as part of their efforts to remain competitive. Poor demand forecasting, overproduction, inefficient management policies and

[8] Later in this paper, we will provide a fuller explanation of how food waste is generated within the industrial food system.

practices, and attitudes towards fresh food all contribute to food waste at the supermarket level (for more details on these phenomena, see the discussion in the next section).

Perversely, certain well established processes that appear to reduce waste may actually contribute to it or have less of a positive impact than presumed. O'Brien (2013, p. 202) captures this problem in the observation that, "contemporary policy simply construes the discarding as a link in the chain of surplus management." In this sense, the lines are blurred between surplus and waste. Midgley (2013) argues that secondary markets in surplus food, such as food banks, are designed to protect primary markets, by providing outlet for lower quality goods and ultimately helping to regulate prices.

Equally difficult, the efforts of one part of the supply chain create challenges for other parts. Under current food system conditions, reducing food waste on the demand side will have mixed outcomes regarding overall welfare of agri-food firms. For consumers, reducing individual food waste is generally beneficial as less money is spent on food purchases. Conversely, reducing consumer food waste may not be in the best interests of agri-food producers and suppliers as there is reduced demand for food products. However, producer and supplier welfare may not necessarily decline if consumers are using saved expenses for the consumption of other higher end commodities (Rutten, 2013)[9].Typically, as food waste reduction strategies are only measured against a cost-benefit ratio, consideration for the distribution of welfare and larger ecological impacts are omitted (Parks & Gowdy, 2013).

Consumer food waste is often attributed to behavioural responses that may be facilitated in part by the structure of food retailing and manufacturing (e.g. packaging sizes, one-stop stock-up trips, supermarket locations). Some other identified causes of consumer food waste include high aesthetic standards for produce, cooking/preparing too much, not using the food in time, and a lack of confidence using leftovers (Gooch et al., 2010). Some studies (Jaffe & Gertler, 2006) partly ascribe the rise in food waste to consumer deskilling, which refers to the intentional and unintentional loss of basic food knowledge, such as proper food handling, storage, and preparation. As Evans (2012, p. 12) showed from his ethnographic work with south Manchester U.K. householders, food waste emerges from the intersection of "time, tastes, conventions, family relations and domestic divisions of labour' within 'the material context...of domestic technologies, infrastructures of provision and the materiality properties of food itself". Watson and Meah (2013, p. 116) put it another way: "Food waste is in this way the fallout of the organization of everyday life. The location of practices of household food provisioning within broader patterns and rhythms through which everyday life is accomplished can easily work to displace enactment of concerns to avoid waste."

We return to these themes later in the paper when discussing the framing of food waste interventions and the types of solutions consistent with that framing.

[9] Since we can only eat so much food, saving money on waste reduction does not necessarily mean buying more food with it, but possibly buying different kinds of foods. But this involves a substitution that might, in a cascading way, result in other producers suffering.

Waste in the industrial food system: A fuller description

In this section, we provide some summary descriptions of waste in the modern industrial food system. This sets the stage for our later discussion of priority strategies for redesigning food systems. Unfortunately, while it is possible to qualitatively describe multiple aspects of waste, in many cases, there are limited data available to provide a more robust understanding of it.

Land use waste (from MacRae, Lynch, & Martin, 2010)

It used to be that farmers would adapt cropping and livestock production to soil and climatic conditions. Now they use chemical fertilizers, pesticides and irrigation to "compensate" for biotic and abiotic deficiencies, often unsuccessfully. The consequence is that soil quality is not necessarily well matched to crop production practices that minimize resource expenditure. Related to this, crop and animal production are often separated (sometimes referred to as stockless systems and factory farming) and nutrients from animal manure are squandered, because there is insufficient cropping to optimize use and transporting nutrients to other farms is too expensive.

In Canada, farming is considered a private sector activity governed by private property rights. Consequently, there is limited landscape level planning and execution to ensure that cropping and animal production reflect the ecological realities of a region. Such planning is more complex than just matching crops to soil types. Some degree of specialization (within the bounds of system rotation and diversity requirements) might occur based on landscape features and farmer collaboration (e.g., sharing land to create suitable rotational crop patterns and building on landscape integrity). Of course, the competition with other land uses, particularly urbanization, makes such planning more complicated. However, many urban areas also have land that could be used for food production, especially if such production is organized to avoid competition with peri-urban producers.

An undetermined, but significant, amount of high quality land area is devoted to non-food uses, including tobacco, floriculture, landscaping plants, horse racing, and crops for beverage production. Many of such lands may be better suited to food crops, with non-food crop production shifted to less valued locations.

Nutrient inefficiencies (from MacRae et al., 2010)

The shift to synthetic nutrient sources from biological ones creates new inefficiencies in nutrient use and the energy expended to produce them. This is particularly acute for nitrogen, the most energy expensive of the main crop nutrients. For example, N use efficiency of cereals decreased globally from 80% in 1960 to about 30% in 2000 because of inefficiencies related to synthetic N utilization (Erisman, Sutton, Galloway, Klimont, & Winiwarter, 2008). Green manure nitrogen recovery is typically much higher than synthetic N (70 to 90% vs. 30 to 50%) but is spread out over much longer time horizons with usually only five to ten percent available in the first following crop (Crew & Peoples, 2005). Consequently, it requires more sophisticated management and seems “inconvenient” relative to synthetic N.

Regarding plant varieties, the focus in plant breeding on high optimal harvest index may reduce overall system efficiencies associated with the plant, and increase off-farm export of nutrients. Farming systems that make better use of the non-human edible parts of the plant – either for organic matter, for animal feed, for bedding, or for weed management (taller, more competitive plants with lower nitrogen requirements) – is desirable.

Water waste

As discussed above, animals, crops and rotations are not usually selected for the prevailing moisture conditions; thus, irrigation is often required. This is problematic for food crops, but even more so for irrigation of exotics and non-edibles destined for export markets. Irrigation systems are not very efficient, frequently with poor timing and targeting, inefficient distribution and pumps. Around 70% of water use in the world is for irrigation, therefore with food waste, a great deal of water is used ineffectively (Cuellar & Webber, 2010).

Processing also contributes to water waste. In 2005, the Canadian Food and Beverage Industry (FBI) accounted for about 20% of all water withdrawals of manufacturers. Of this, 77% of water taken was discharged, 19% was incorporated into product, waste sludge and solid waste, or evaporated and only four percent was reused (Maxime, Arcand, Landry, & Marotte, 2010).

The amount of water used each year to grow and produced lost and wasted food would fill 70 million Olympic-sized swimming pools (UNEP, 2013a). U.K. food waste used six percent of the U.K.’s water requirements and nearly twice annual household water use (WRAP U.K., 2011).

Solar inefficiencies

Modern agriculture is designed around annual plants instead of the generally more energetically efficient perennials. And most of the annuals are C3 plants, rather than the more optimal C4s[10]. The C4s used are typically highly mismanaged in energy terms. Additionally, many fields are not properly oriented for solar capture and structures to capture solar energy are poorly designed, e.g., greenhouses.

As energy is always lost the more consumption stages it passes through, eating closer to the sun definitely helps with overall system energy efficiency. When humans consume products from animals that are fed crops humans can consume, or on land that can appropriately be

[10] C3 and C4 refer to the metabolic pathways of carbon fixation in photosynthesis. Fewer plants are C4 and in evolutionary terms are likely more recent developments. C4 fixation is thought to be more metabolically efficient than C3.

devoted to human food crops, energy and land use efficiencies decrease. In contrast, efficiencies tend to increase when animals are fed plant matter that humans cannot digest (including crop residues), on land better suited to pasture than field and horticultural crops (MacRae et al., 2010).

Metabolic inefficiencies (Smil, 2001)

North American agriculture focuses excessively on large animals that are metabolically inefficient. Cattle are very popular in North America, but pigs have 40% lower energy requirements than would be anticipated from their size, largely because of low basal metabolism. Cattle have much higher basal and reproductive metabolism, although dairy animals have a favorable conversion ratio for milk. Pigs also tolerate a wider range of environments. Chicken and eggs are next on the energy conversion scale, suggesting they warrant more attention in landscape level planning for energy efficiency. Ultimately, fish are much more efficient feed converters than farm livestock, so it makes sense to devote more attention to ecological herbivorous and omnivorous fish systems in the longer term.

To optimize both human and animal feeding systems, ruminants should eat primarily forages/grass and monogastrics residues and seeds (other than the dominant crop seeds). Other countries have more appropriate balances. For example, only five percent of human edible grains are fed to livestock in India compared to 60% in the U.S. Crop residues and wastes, feed oil seed crush, processing residues, and lower quality feed grade crops should be more effectively used for livestock. As well, pasturing hogs and poultry is feasible as part of the diet (Honeyman, 2005). Reducing feed losses will improve overall system efficiency. Additionally, animals fed such a diet tend to be leaner. The U.K. Institute of Grocery Distributors (IGD) and the Lean Enterprise Research Centre (LERC) found, for red meat production, that producers were feeding animals until they were overly fat. This is not only a waste of feed, but also costs processors who have to put resources into trimming off unnecessary fat (Gooch et al., 2010).

In the dominant production models, animal are typically raised in environments that are not conducive to their innate behaviours and this typically requires more energy to sustain them. For example, many beef cattle breeds are bred for primarily outdoor living and do not require barns. Pigs do well in more open structures such as hoop houses and open air sheds (Honeyman, 2005). Such systems have lower energy use associated with the structure, and may have lower overall energy use depending on the feeding regime (the biggest consumer of energy in hog systems) (Honeyman & Lammers, 2011).

Human overconsumption (luxus consumption)

Smil (2004, p. 22) observes from a population level perspective on biological calorie requirements vs. current consumption that,

> weighted means for entire populations are rarely above 2,000 kcal/person. This means that per capita gaps between average availability and actual consumption are now greater than 1,000 kcal/day in every high-income country, with maxima approaching, or even surpassing, 1500 kcal/day. In order to account for inevitable food losses and to provide an adequate safety margin the average per capita food supply should be 30% above the needed mean of 2,000 kcal/capita, averaging no more than about 2,600 kcal/capita.

In his view, proper allocation of calories would feed an additional 350 million people.

Supply chain waste

Waste happens in multiple ways along the supply chain and for multiple reasons.

Farm products - Field losses in Canada were estimated by Gooch et al. (2010) to be nine percent of total waste. As discussed earlier, nutritious and safe food does not necessarily leave the farm, for a number of reasons including: cosmetic requirements[11] that do not make it worth harvesting; harvesting inefficiencies (human or machine); low prices; and losses during on-farm primary processing and storage. Given levels of field waste, significant amounts of food degrade on the field surface in ways that are suboptimal for nutrient uptake by subsequent crops. Food that is harvested and then rejected is often left in cull piles and not composted or fed to animals. Farmers often do not have room in their packing house for lower grade products. An Ontario produce farmer, speaking prior to Ontario's changes to the produce grading system, argued that, "even though the Canada No. 2 grade could be sent to processors or manufacturers, we don't usually bring them out of the field." Processing prices are typically substantially below fresh market prices and farmers usually need an advance contract with processors to make the secondary product supply chain work; that is, they cannot necessarily sell product to processors that was grown for the fresh market but failed to meet the standard. On top of this, the standard boxes used to ship produce can only accommodate a certain size in order to meet quantity descriptions on the box, thereby providing a further incentive to leave food in the field (Schneider, 2008). When a producer does have a contract directly with a retailer, those specifications are usually more exacting than government grading standards. A major Canadian retailer executive stated that, "we don't accept those [government] standards because they're minimum standards. What we do is create our own quality standards, which we call quality specification." For instance, this retailer has about 850 quality specifications for their fruits and vegetables alone (personal communication, senior food retail executive, February 17, 2011).

[11] Note that some provinces, including Ontario, have largely eliminated vegetable and fruit grading standards.

Processing and packaging - Nutritious food is lost during processing for several reasons. It may be deemed unsuitable, the food may be substantially trimmed to suit the process, the batch can be lost due to errors, motion inefficiencies can damage the batch, too much was purchased for demand, or pre- and post- processing storage was ineffective. Gooch et al. (2010) estimated packaging / processing waste at 18% of total food waste, but how much is edible and results from errors and process inefficiencies is not clear. From their discussions with Canadian processors, they concluded that 10 to 40% of the products handled at the processing stage are wasted. The Québec Ministry of Agriculture, Fisheries and Food estimated that between one-fifth and half of the industry's food waste was fit for consumption in 2012 (Fortin, 2014).

Non-perishable food packaging errors occur during the manufacturing process. A significant percentage of this product ends up in the charitable food system, so some of it is consumed. However, food banks are sometimes subsequently forced to dispose of the donated goods, but how much waste this generates is difficult to determine. There is some evidence that the charitable system makes it more feasible for manufacturers to donate (and often receive tax donation credits) than to repackage the goods (Midgely, 2013).

Distribution and shipping - The sometimes convoluted movement of food within a region likely increases the gap between harvest and store purchase. Losses during the shipment of fresh goods from farm to retail, especially with refrigerated, long distance hauls, can result in load rejections at retail or culled pallets. An interview with a senior executive at a major Canadian retailer revealed that in the late 2000s the company was rejecting 75 truckloads of produce per week at the distribution centres (DCs) across Canada that amounted to about 2,722 tonnes a week or 141,570 tonnes a year. This did not include what the retail stores rejected from the DCs. McCallum et al. (2014) provide details on the supply chain challenges facing major retailers as it relates to wasted produce. The buyer protocols can also create waste in the meat sector. Waste along the chain due to inconsistency in carcass composition and production adds an estimated 10% to the end price as meat not meeting specifications is rejected somewhere along the chain (Gooch et al., 2010). Gooch et al. (2010) estimate distribution losses at three percent of total food waste in Canada.

Cooling - Problems with cooling infrastructure along the supply chain (from farm to home fridge) leads to waste. The perishable food system runs on cooling and freezing and a significant percentage of the cooling units have been old (Garnett, 2006). The opportunities for failures, resulting in lost food, are significant. As well, not all horticultural producers can afford sophisticated field chilling equipment. Pre-cooling acts to remove the heat stored in produce from the field. This affects particularly local growers who do not usually have the resources to field chill their produce prior to shipping. Product immediately loses shelf life, and without being able to move local food quickly, retailers risk serious losses.

Retail - Buyers often misforecast requirements (Karolefski, 2015) and then reduce orders when conditions suddenly change, leaving the suppliers without a sale (McCallum et al., 2014). This occurs because retail buyers typically have more economic clout than suppliers and contracts shift economic risks to the weaker actors in the supply chain. Alternately, retailers may be afraid of shorting so they over-order. The amount of available food per person in retail stores has increased during the last decades (Gustavsson et al., 2011). The appearance of abundance is believed to be attractive to consumers, thus increasing sales in the long-term, even if it generates waste in the short-term (Gunders, 2012). Constant stock rotation, however, promotes waste as discerning consumers favour newly stocked produce over those that are close to expiry (Gustavvson et al., 2011). Overstocking can also lead to over-handling by both staff and customers, which may damage items and add to waste generation (Gunders, 2012). Alternately, buyers may focus on "deals" from international suppliers, and purchase at volumes to make the deal happen, even if it doesn't line up with demand (Mena et al., 2011).

From retail document analysis and interviews conducted by our team, we estimated total in-store shrink (including waste and theft) by Canadian retailers (Table 2)[12].

Table 2: Estimated shrink levels for different product categories in supermarkets (adapted from Kohn, 2011)

Department	Shrink levels (%)
Produce	8 to 11
Bakery	10 to 12
Grocery	0.5
Meat	3 to 4
Deli	6
Meal solutions	8

On average, a typical supermarket's targeted shrink is six and one-half to seven percent of everything that gets purchased for sale. Reducing shrink from nine to seven percent would represent a significant reduction and make a huge difference to the bottom-line. To limit shrink, a store must counteract prominent driving forces for freshness and quality at a low price.

Restaurant - Gooch et al. (2010) estimated that restaurant/food service waste represents eight percent of total Canadian food system waste. In U.S. restaurants, diners wasted nine percent of the meals they bought, partly because of increased serving sizes (Lipinski, Hanson, Waite, Lomax, Kitinoja, & Searchinger, 2013). Since the 1970s, there have been significant increases in portion sizes in the U.S. (Nielsen & Popkin, 2003). For example, the Centers for Disease Control (CDC) documented two and one-half to four fold increases in serving size for certain popular fast food items between the 1950s and the present day (CDC, n.d.), the average pizza slice has

[12] Note that in our studies, retailers were very reluctant to provide precise figures on shrink, so we were forced to estimate from secondary sources.

increased by 70% in calories and the average muffin has more than doubled in calories. Portion sizes served in restaurants and other food service establishments can range from two to eight times larger than the USDA's recommended standard serving sizes (Regional Municipality of York, 2013). This appears to have carried over into Canada as well, though data are less available.

WRAP U.K. found in a survey of a range of food service operations that 21% of food service waste is from spoilage, 45% is from food preparation and 34% from plate waste. Different types of restaurants show different profiles, for example, there is lower plate waste in fine dining establishments and higher waste from kitchen prep, while restaurants without sit-down have contrasting ratios (Williams, Leach, Christensen, Armstrong, Perrin, Hawkins et al., 2011). In many restaurants, a lack of trained chefs and fixed menus can limit capacity to adapt to excess inventory, whereas restaurants with skilled chefs and weekly menu changes are less likely to waste food. In fact, the reduced waste is part of how some keep prices affordable (Rosenblatt, 2009). The FAO report (Gustavvson et al. 2011) noted that certain kinds of procurement practices mean that more food preparation happens off-site so the waste is generated elsewhere in the supply chain (in North America, suppliers to food service such as Sysco). A detailed analysis of profit-making hospitality operations found that, "two-thirds of the food that was thrown away could have been eaten if it had been better portioned, managed, stored and/or prepared, with the remaining one-third consisting of items that are 'unavoidable waste' as they are not usually consumed (e.g. banana skins, vegetable peelings)" (Williams et al., 2011, p. 4).

Consumer – Food waste in the home includes uneaten food in the refrigerator, plate waste and liquids poured down the drain. Gooch et al (2010) estimated that 51% of waste is generated in the home, revised to 47% in their follow up work because of the addition of higher waste estimates in earlier stages of the supply chain (Gooch & Felfel, 2014). In their study of U.K. food waste, Quested and Johnson (2009) concluded that 64% was avoidable edible waste, over half of which was not consumed in time and 41% was a result of over-serving. Another 18% was potentially avoidable, depending on family consumption patterns and only 18% was inedible, requiring consumption by other organisms or composting. Following a 2014 audit, Metro Vancouver concluded that over 50% of the food being wasted was avoidable (Metro Vancouver, n.d.).

However, as discussed earlier, structural dimensions across the supply chain contribute to food waste in the home, particularly phenomena such as the weekly stock-up trip (often associated with poor urban planning that positions large stores at some distance from neighbourhoods), store promotions that encourage overbuying, the failure to carry small unit sizes, confusing date labelling, store designs that encourage impulse buying (Ontario Public Interest Research Group, 1990) and consumer deskilling (Jaffe & Gertler, 2006). Certainly consumer behaviours contribute to the situation (Parfitt et al., 2010), but resolving them is not just a question of consumer education as many propose.

Nutrient recovery - Nutrients are lost because of inefficient recovery from compost and sewage sludge. "In Canada, approximately 30-40% of all municipal solid waste is composed of organic material...and upwards of 25% of residential solid waste may be food waste." (Forkes, 2011, p 62) Many regions do not have backyard, residential curbside or commercial composting programmes. Those that do, often have inefficient composting processes, with losses and poor quality end-product that is not used for food production. Regarding human waste, we excrete up to 90% of the total protein consumed. "Lind et al. (2001) estimated that the recycling of nutrients present in domestic wastes could replace 35-45% of fertilizers needs, 20-25% from the recycling of nitrogen in urine alone." (Forkes, 2011, p. 63) Only about 20% of mined phosphate rock actually makes it to our food, with urine and feces losses a significant part of the inefficiency (Ashley et al., 2011). Unfortunately, most municipal sewage is contaminated with industrial materials and cannot be applied safely to farmland (although the practice continues). As a result, incineration, composting and landfill are the most common alternative disposal methods.

Clearly, waste is extensive across the entire food system with many structural processes responsible for the current deficiencies. There are, however, many possible improvements that we discuss in the next section.

Critical next steps to minimize waste and reduce pressures on yield increases

Food waste reduction frameworks

Waste is on the radar and many firms have been doing positive things. However, much of that effort is misdirected and voluntary, with limited uptake by the actors critical to improving the situation. "[T[he links between the various economic and cultural processes that give rise to waste, [remind] us that it is essential to research food waste as it appears within different national, institutional and regulatory contexts." (Evans et al., 2013, p. 10) Our strategic approach in this paper, then, is to create a regulatory environment in Canada that supports many of the positive undertakings, but essentially forces most actors to participate in a way that addresses root causes of the problems. This is not to discount the many things that firms and individuals are doing, but the focus here is on interventions involving the state.

This strategic approach is framed by a number of concepts. First, a food chain approach is critical and represents a departure from many earlier approaches that tended to focus on individual sectors (Jackson, Ward, & Russell, 2006). "While the majority of food waste occurs at the consumer level, improving the management of agri-food value chains would have the greatest long-term impact on reducing food waste, and the resulting economic and environmental impacts."(Gooch et al., 2010, p. 10) Concluded WRAP U.K. (2011a), "the greatest successes so far have come from addressing the whole supply chain collectively, as experience shows that reducing waste in one area may, in fact, create it somewhere else." Supply chain analysis provides a clearer picture of various participants and may lead to greater systemic efficiency (Hodges et al., 2011). As Gille (2013, p. 40) argues,

> We need to do two things in our analysis: first, stop conflating the location with the cause of waste; and, secondly, make visible how resource waste and food waste are interconnected.... If we want to find places for intervention, those relations that cross not only geographical and political boundaries but also scales must be analysed. The problem for policy-making, however, is that it is exactly these types of complex and multi-scalar forms of food waste that are the hardest to quantify and therefore the hardest to eliminate....If food loss is caused by non-human factors—weather or pests—the solution is greater mastery over nature: that is, technological innovation. However, if food loss is caused by social arrangements, the solution resides in new institutions and the reorganising of structures leading to systemic loss. My general view is that both accidental/natural and systemic/social causes of food waste must be attended to.

Second, we employ an agroecological interpretation of waste. In such an approach, the food system is a production–consumption–recycle system (Hill, 1985), in which soil organisms play a fundamental role in transforming organic material into energy, nutrients and water that can be used in subsequent production cycles. In this sense, there is no waste, only food for other processes and organisms. Consistent with this, human survival has historically depended on consuming all edibles and using inedibles primarily for other purposes– shelter, clothing, animal feed (essentially a secondary edible use), tools and production, and sometimes heating / cooking fuel. So what hierarchies and instruments encourage optimal utilization of edible food before inedible food goes into secondary processes?

An agroecological approach demands changes to traditional food waste management hierarchies. The European Commission’s Waste Hierarchy Directive in 2008 (EC, 2012) (in order from most preferred to least preferred) only partly reflects such ecological principles:

- waste prevention (non-waste)
- preparing for reuse
- recycling
- recovery
- disposal

The U.S. Environmental Protection Agency’s (2014) food recovery hierarchy (in order from most preferred to least preferred) is somewhat more reflective of an agroecological approach:

- source reduction: reduce the volume of surplus food generated
- feed hungry people: donate extra food to food banks, soup kitchens and shelters
- feed animals: divert food scraps to animal feed
- industrial uses: provide waste oils for rendering and fuel conservation an dofood scraps for digestion to recover energy
- composting: create a nutrient-rich soil amendment
- landfill/incineration: last resort to disposal

Better frameworks and hierarchies than these are required because otherwise the capitalist drive to surplus accumulation captures food waste as energy or other secondary processes and makes those processes actually more important than ensuring people have access to a nourishing diet. O'Brien (2013) captures this reality well in his story of freegans prosecuted in Europe for stealing an energy resource, that is, food that had already been dumped as waste but was to be collected by a biomass energy producer. Many proposals from industry and government to improve food waste management unfortunately facilitate this drive to surplus accumulation (for an example of such proposals, see Gooch et al., 2010).

To correct for the causal forces identified above, we propose the following hierarchy from which to design regulatory structures and processes (and provide preliminary broad observations on current challenges associated with fulfilling the hierarchy):

- Level 1: Edible food for direct human consumption at minimum resource expenditure. Challenges: tailoring resource quality and quantity to food production; shifting all producers to sustainable practices; redesigning processing to minimize waste generation and maximize resource use efficiencies; sustainable procurement within agrifood firms; demand-supply coordination for edibles, animal feed and secondary processes.
- Level 2: Animal feed (and pet food) without human edibles, but includes human inedibles, such as corn cobs, skins, husks.
  Challenges: removing most human edibles from animal feed which has tremendous implications for animal production; limited number of animal feed processors and distributors able to cycle human inedible food waste to animals, a task more feasible for the farm and processing sectors, but more difficult for retail, restaurants and households.
- Level 3: Human and animal inedibles directed to compost and industrial applications, including waxes, leather and other clothing, chemicals, pharmaceuticals, construction materials, plastics, energy and inputs (e.g., compost).
  Challenges: the need to minimize farmland use for direct energy production unless land quality makes food production impractical; careful targeting of health applications since many plants are essential to the pharmaceutical sector; designing plastics and chemicals from secondary not primary food materials; efficiently using

land for inputs, such as breeding stock and seed. In the case of most farms where energy is produced, it should be consistent with an agroecological approach; that is, it should be a coherent and integrated complement to food produced. If energy crops are planted, the system must be highly efficient, otherwise other measures make more sense in terms of opportunity costs (for more, see MacRae et al. 2010).

- Level 4: Sewage sludge and humanure application to farm land to close nutrient and energy loops.
  Challenges: gap between the potential purity of individual household humanure (assuming the family is healthy and not requiring significant medication) and the end products arising from current residential human waste collection and treatment systems; need to separate residential and industrial sewage and improve sewage treatment processes

Third, we use the Hill and MacRae (1995) Efficiency–Substitution–Redesign[13] framework. This framework serves as both a guide to action, and an indicator of progress. In this framework, Stage one (Efficiency) strategies involve making minor changes to existing practices to help create an environment somewhat more conducive to the desired change. The changes would generally fit within current policy making activities, and would be the fastest to implement and may require minimal additional resources. Second stage (Substitution) strategies focus on the replacement of one practice, characteristic or process by another, or the development of a parallel practice or process in opposition to one identified as inadequate. These typically require more time and resources than Stage one strategies. Finally, third stage (Redesign) strategies are based fully on the principles of ecologies, particularly agroecology, organizational ecology, political ecology and social ecology, and are fully elaborated to address complexity (the earlier stages benefit from an understanding of complexity, but are not in themselves necessarily complex to execute). They take longer to implement and demand fundamental changes in the use of human and physical resources. This final stage, however, is unlikely to be achieved until the first two stages have been attempted. Ideally, strategies should be selected from the first two stages for their ability to inform analysts about redesign (the most underdeveloped stage at this point) and to contribute toward a smooth evolution to the final stage.

A presumption of this framework, then, is that policy change in the Canadian food system is largely evolutionary. It is a longer-term reformist approach, with the dominant structures progressively adapting to policy pressures, ultimately leading to a profound redesign of the food system. Thus, the redesign stage is visionary, but presumes progressive layers of transition leading to its realization. We assume that there are no changes to the Canadian constitution and this limits what and how redesign efforts can be brought to bear. As highlighted later, the

[13] Note that there are many transition frameworks. See MacRae and Winfield (2016) for a review pertinent to food policy themes.

Canadian constitution is a significant brake on food system innovation and we account for that in our proposals.

Using this transition framework, and our proposed food hierarchy, we elaborate below on policy and regulatory initiatives to reduce food waste. To date, the market has proven itself unable to manage food resources consistent with the hierarchy of uses proposed here. Although there have been improvements in food firm behaviour, particularly at the efficiency stage, individual firms will not be able to identify wider structural problems and coordinate changes across firms in order to dramatically reduce food waste. Consequently, there is a significant role for the state, particularly beyond the efficiency stage. For each initiative, we also identify the most significant waste problems addressed (following the description in the previous section, Waste in the Industrial Food System).

Efficiency initiatives

As it relates to food waste, the Efficiency stage is characterized by technological efficiencies, but with attention to O'Brien (2013), excluding initiatives that reinforce capital relations and facilitate capitalist surplus management. Equally important, while this stage can address issues of consumer behaviour, it should do so in a way that does not blame individuals for what are wider structural phenomena.

General

- **Better information on waste and resource inefficiencies**
  Problems addressed: All

With less than five percent of agricultural research funding allocated to post-harvest systems and loss (Parfitt et al., 2010), additional funding from agencies such as the Natural Sciences and Engineering Research Council of Canada and Social Sciences and Humanities Research Council would potentially enhance our understanding of food waste. In addition, definitions of food waste and standards for measurement are required to promote consistency and useful comparisons across studies. Reliable waste estimates and an understanding of the causes are needed to identify where food waste can be efficiently minimized. Policy makers (and private businesses) need reliable information to conduct cost-benefit analyses of specific waste-reducing initiatives (Buzby & Hyman, 2012).

- **Target setting**
  Problems addressed: All

Improved research on food waste permits better goal setting and targeting of initiatives at multiple levels in the policy system.

> In the European Union (EU), the single biggest transition in waste and waste policy is the 1999 Landfill Directive (1999/3/EC); a policy that set out to reduce the negative effects of sending waste to landfill in relation to the environment and human health. This document set legally binding targets to which member states are to adhere...The targets are exceptionally ambitious–not least the obligation to reduce biodegradable waste (the category to which food waste belongs) to 35 per cent of 1995 levels by 2016, or by 2020 for some countries (including the U.K.) (Evans et al., 2013, p. 17).

In the U.K., the existence of this directive produced the Waste and Resources Action Programme (WRAP), an independent non-profit organization with an international reputation for its research, expertise, and advice in a number of areas including food waste reduction. WRAP U.K. sets out to minimize resource use and divert valuable waste from going to landfill. They work in partnership with a number of retailers and manufacturers to help achieve these goals. Being funded by government bodies such as the Department of the Environment, Food and Rural Affairs (DEFRA) allows them to build evidence on food waste and the necessary measures to reduce it.

Both the E.U. and the U.S. have 50% food waste reduction targets, Europe by 2020 and the U.S. by 2030 (National Zero Waste Council, 2016). As yet, Canada has no national targets, but the National Zero Waste Council (NZWC) has called for a Canadian target in line with that of the U.S. (NZWC, 2016). Several regions have modest targets. For example, Metro Vancouver's objective, working in collaboration with WRAP U.K., is to reduce household food waste by 10% by 2018 (Cech, 2016).

In Ontario, supermarkets, restaurants and manufacturers (among other businesses) must conduct a waste audit and create a waste-reduction work plan, and update that audit every year under Regulation 102/94 of the Environmental Protection Act. Smaller operations are exempt. The Recycling Council of Ontario (RCO) and the Ontario Ministry of the Environment and Climate Change (MOECC) give businesses advice and information on how to implement a waste diversion program. Although the MOECC clearly identifies that a successful waste reduction programme has multiple dimensions, the Regulations do not require businesses to include all streams of waste in their action plan, so food waste is often left out of companies' diversion programmes. The MOECC should set specific reduction and diversion targets (see discussion below regarding the Waste-free Ontario Act) for each stream, including organic waste. Opportunely, the supermarket chains have voluntarily included food waste in their diversion programs for various reasons discussed below. Unfortunately, the lack of transparency from these waste audits makes it difficult for those outside the retail sector to ascertain whether these companies are meeting any of their commitments.

Regarding processing, as some processing marketing boards have regulated contracts (e.g., the Ontario Vegetable Processing Marketing Board), waste reduction could become a priority of contract execution with sectoral targets and product specifications so as to reduce waste.

Edible food for direct human consumption at minimum resource expenditure

- **Educational campaigns**
  Problem addressed: Consumer behaviour in household, retail outlets and restaurants, luxus consumption

Educational campaigns are often a preferred strategy because they can easily be implemented by the private or public sector and may increase consumer knowledge and awareness of food waste. They are politically acceptable because of their low-cost and accommodation of current food business models. Agri-food corporations may even benefit by promoting positive images of their commitment to consumer cost-savings, sustainability, and feeding the hungry. Overall, educational campaigns act as a step towards changing long-term consumer attitudes and behaviours regarding food waste.

Part of the challenge is the complex array of household characteristics, beliefs, attitudes and behaviours that influence food waste, some of which appear to be counter-intuitive (cf. Parizeau et al., 2015). Awareness does not always lead to greater understanding of how eaters contribute to the problem and what they can do to reduce waste (Guelph Food Waste Project, 2014). A survey of U.S. households found that 63% of consumers felt food waste was a problem, yet only 34% believed that their household contributed to it (Watson, 2014). Similarly, when respondents from Guelph, Ontario were asked what they could do to reduce waste, almost 40% could not think of anything (GFWP, 2014). Some studies show that once people are aware of the value of their losses, then there is more commitment to handling food more effectively (Hodges et al., 2011). Metro Vancouver appears to be banking on this in their food waste campaign, estimating that food waste is costing the average household $700/yr (Metro Vancouver, n.d.). Parizeau put forth a similar national estimate from her work, $760/yr/household (Tobin, 2016). Campaigns can also help consumers improve food purchasing skills, meal planning, leftover use, gauge what is safe to eat, and interpret date labeling. Additionally, interventions can help consumers develop a certain waste tolerance, for example, to accept a package of strawberries, even if one strawberry is damaged or spoiled (Terry, Mena, Williams, Jenney, & Whitehead, 2011).

Education campaign architects must understand the motivations that drive consumers to waste and how consumers frame this issue. Many households do not perceive food waste to be a significant environmental problem; rather, it is often viewed first and foremost as a social issue (Parizeau et al., 2015). Watson and Meah (2013) suggest environmental campaigns will not be very effective unless the ethic of thrift is linked directly via environmentalism. As such, educational campaigns may more effectively shape consumer behaviour by framing them with social impacts, rather than strictly environmental or economic ones[14]. According to this thinking, food waste reduction campaigns should use guilt generated from throwing out edible food when many others go hungry.

There are several approaches and tools available to implement educational campaigns. One is to provide proper storage and handling instructions, near the product display, on small take-away cards. Another example is mobile phone applications that provide educational materials and tools to assist consumers with reducing their waste. In addition to Facebook and Twitter, WRAP U.K. introduced the Love Food Hate Waste App at no charge to communicate with consumers[15]. In the WRAP U.K. partnership with Metro Vancouver, such campaign strategies are being attempted in the Canadian setting (Goodwin, 2014). A third example could be radio, television, or print public service announcements, such as the food waste commercial commissioned by the Scottish government in 2014[16]. Provinces may have existing legislative frameworks to support this, for example, Ontario's Environmental Protection Act provides the means to finance educational campaigns.

Another common approach is to create "Days". On March 5 2014, a New Democratic Party (NDP) MP tabled a motion in the federal House of Commons:

> That, in the opinion of the House, the Government should: (a) declare October 20th of each year National Day Against Food Waste; (b) develop a comprehensive pan-Canadian plan to reduce food waste by (i) educating Canadians about food waste through a national campaign, (ii) facilitating the donation of safe, unsold food from the private sector to community organizations and food banks; (iii) putting in place various other measures to reduce the environmental impact resulting from the production of unused food (NDP, 2014, para. 6).

The motion also called for national targets and a national food waste reduction strategy but failed to pass.

- **Food label changes**
  Problem addressed: Consumer behaviour at retail, restaurant and household, luxus consumption

Another efficiency stage measure involves changes to food date labels. A variety of date labels are used on foods, including "sell by", "use by", best before" and "expiration" dates. In Canada, best before dates are required for pre-packaged foods that will keep fresh for 90 days or less; "use by" labels apply only to pre-packaged fresh yeast; and "expiration" dates are required for

[14] Note that WRAP .U.K. has chosen to focus primarily on the economic and environmental dimensions.
[15] Love Food, Hate Waste details at: http://www.lovefoodhatewaste
[16] Information is available at Greener Scotland, http://www.greenerscotland.org/

select products like infant formula (Canadian Food Inspection Agency, 2014). Of the various food date labels, best before dates cause the most confusion for consumers. They describe the anticipated amount of time that an unopened food product, when stored under appropriate conditions, will retain its freshness, taste, nutritional value, or any other qualities claimed by the manufacturer. Therefore, best before dates do not indicate food safety, as food is still consumable after the best before date has passed (CFIA, 2014). Unfortunately, many consumers are unaware that food recently past its best before dates is usually still edible and waste is the result.

The confusion over best before dates, and the subsequent fear of unsafe food, also drives waste at food retail. It has been documented in the U.S. that stores remove items in advance of these dates in order to maintain their image of carrying only fresh products (Gunders, 2012), and presumably the same occurs in Canadian retail outlets.

Although federal regulations dictate how dates are declared (CFIA, 2014), they do not guide how they are calculated. There are some specific guidelines for certain foods and bacteria (e.g., Listeria in ready to eat foods). Other jurisdictions, however, provide more guidance, including New South Wales (NSW) Australia (NSW Food Authority, 2010), New Zealand (New Zealand Government, 2012), and the U.K. (Food Safety Agency, 2011).

To ensure greater consistency, as part of pre-market clearance, companies with products covered by Best Before and Expiry date regulations should identify the method of determining durability and a summary of the data that supports the dates they propose. Since the Food and Drugs Act permits the Minister to prevent the sale of products with misleading labels, a regulatory amendment to the effect that the Minister can advise a firm to make changes to its Best Before dates, would then allow for adjustments should the Minister determine the dates to be inaccurate.

An additional initiative would be to post “freeze before” date marks on packaging in combination with best before marks for certain foods (WRAP U.K., 2012). This would require only minor amendments to Food and Drug Regulations B.01.007 (1.1)(c) for prepackaged product having a durable life of 90 days or less and packaged on the retail premises from which it is sold. A comparable amendment would be required to B.01.007(1.1)(b) for a prepackaged product having a durable life of 90 days or less and packaged at a place other than the retail premises where it would be sold. In a similar vein, a French co-op, Les Gueules Cassées, successfully created a “close to date” expiry label for their range of products. Food retailers buy the stamps and add them on any product they think should be discounted up to 50%, including vegetables, yogurt, cheese, deli meats, packaged sandwiches, and hummus (Perreault, 2015). Les Gueules Cassées also has consumer eduction materials and makes donations to NGOs working on food waste. Such approaches could be explored in the Canadian context.

- **Improving food donation**
  Problems addressed: Farm, retail, food service and restaurant waste

There are two key pieces of Ontario provincial legislation that facilitate the redistribution of food for donation. As part of the Local Food Act, 2013, the Taxation Act, 2007 has been amended, providing farmers with a tax credit of up to 25% of the market value for donated produce, in addition to the existing charitable donation tax credit. Additionally, the Donation of Food Act, 1994 protects donors from liability for any risks associated with food donated in good faith. While these pieces of legislation are encouraging, their effectiveness for increasing food donations remains uncertain.

First, potential benefits may not be realized if neither the benefactor nor community food organizations have supporting infrastructure. In a survey of comparable U.S. food manufacturers, retailers, and wholesalers, half of respondents cited insufficient storage and refrigeration at food banks and a lack of refrigerated trucks and drivers as barriers to donating food (Business for Social Responsibility, 2013). In order to facilitate food donation and to bolster the effectiveness of the tax credit, capital grants should be provided to improve transportation and storage infrastructure.

Second, despite the protections provided by the Donation of Food Act, many companies choose not to donate food out of concern for potential liability issues and negative publicity. These fears are unfounded, since the legislation is designed to protect donors except in cases of serious omission and gross negligence. Outreach and education to the private sector by the government and private charities may assist in overcoming this limitation.

Another approach to facilitate food donations is fostering linkages between volunteers and charitable organizations and producers, food retailers, and food service outlets. For example, governments and businesses should encourage innovation in online solutions, such as Ample Harvest, that quickly connect potential donors with community organizations (Gunders, 2012). Coordinating volunteer gleaners from charitable organizations can assist in overcoming high labour costs that deter farmers from harvesting excess or left over fruits and vegetables. Ontario Gleaners provides this service.

France (Chrisafis, 2016) and Italy (Samuel, 2016) have now banned edibles from being thrown out by supermarkets. Instead, they have to be donated. This could be considered in Canada in the future.

- **Technology changes**
  Problems addressed: equipment inefficiencies, distribution, manufacturing and retail waste

Reducing shrink throughout the food supply chain has been possible with technology changes to cold chain management (e.g., making sure all the products and their storage areas, including the truck, are properly temperature controlled), GPS tracking to know where the food is in the distribution chain, and improved packaging. At the store level, technology has improved maintenance of correct storage temperatures, moisture removal (hot air in plant tissue holds more moisture), and prevention of over ripening with ethylene scrubbers and bacteria and mould reduction (e.g., with blue light radiation) (Director, Produce Operations, regional retail chain, personal communication, March 25, 2011). Such technology changes have occurred without significant state regulatory change, but if the state creates performance targets for critical technology systems, then such technology improvements might be accelerated. For example, most motors in cooling systems are old (Garnett, 2006). If the state progressively requires improvements in cooling motors and related cooling equipment, and companies replace older technology with new equipment, then more rapid system wide improvements would result. Under Canada's Energy Efficiency Act and Regulations, administered by Natural Resources Canada, some equipment is already covered (e.g., chillers, self-contained commercial refrigerators and freezers[17]), therefore the strategic direction is to expand over time the range of technologies addressed by the legislation, and to increase the performance requirements for those already covered.

The costs of improving or installing new equipment may be prohibitive for some food chain actors, such as smaller producers and retailers. In the short-term, retrofit grants could help offset their costs, thereby encouraging their participation in waste reduction strategies. Such grants have been used many times in the past to improve residential and commercial energy efficiency.

Additionally, moving into substitution stage initiatives, the regulations should be amended to require technology purchasers to accelerate their replacement of old technology. The current regulations apply to the sellers / dealers, but the buyers are not currently obligated to replace their old technology. Section 21 (e) of the Energy Efficiency Act states that the Minister: "(*e*) undertake such other projects, programs and activities as in the Minister's opinion advance that purpose [energy efficiency] ". Under that authority, buyers could be required to purchase such equipment on an accelerated schedule. Constitutionally, such an intervention could be justified under the criminal law power of the Dominion that authorizes initiatives to improve the environment (see Lucas & Cotton, 2013).

- **Packaging changes**
  Problems addressed: manufacturing, distribution, retail and household waste

For many perishables (e.g., strawberries), packaging has not changed substantially in recent years, but there are examples of promising improvements. U.K. grocer Marks and Spencer's extended the shelf life of strawberries by two days in their stores by inserting small ethylene absorbing strips in packages. It reduced waste by four percent (Business Green, 2012). Another technological advance is heat-sealed lids that considerably reduce pack weight while still maintaining product protection (Terry et al., 2011). To promote the use of more protective or innovative packaging by Ontario producers and retailers, producer and retailer organizations can disseminate information to their members on the potential of packaging improvement to reduce

[17] A guide to Canada's energy efficiency regulations can be found at: http://www.nrcan.gc.ca/energy/regulations-codes-standards/6861

waste. Consumers can also be informed through the use of educational campaigns, as discussed previously.

- **Size and portion changes, sales and returns**
  Problems addressed: restaurant and household waste, luxus consumption

Packaging sizes are also problematic, with many too large for small households and serving sizes in restaurants too large for many eaters. Smaller size options are desirable to reduce waste (Gooch et al. 2010).

Such measures can be facilitated by regulatory change. For example, modifications to the Canadian Consumer Packaging and Labelling Act (CCPLA), could widen state authority for food waste reduction. Some possible changes are outlined in Table A1 in the Appendix. Comparable changes would also be required to provincial regulations, such as the Ontario Farm Products Sales and Grades Act (see Table A2 in the Appendix). The associated regulations could be altered to forbid "buy one get one free" (BOGOF) sales for products and only permit "buy one get one free later" (BOGOF-L) sales (for example, a Tesco U.K. programme allows the free item to be picked up within 2 weeks). The Minister could also modify regulation 7 to restrict the ability of buyers to make last minute reductions to orders. As highlighted above, this often leaves the supplier literally holding the bag, with nowhere else to sell product and it goes to waste.

Regarding restaurant portions, as discussed above, the dominant approach generates considerable plate waste and contributes to overeating and associated health problems. Most food premises regulation is implemented at the provincial and municipal levels, but focuses primarily on food safety and does not serve well the changes proposed here. Federal and provincial food labelling regulations address primarily food retail establishments. However, a broad coalition of health advocates, first spearheaded by the Centre for Science in the Public Interest Canada (CSPI), has been calling for restaurant labelling. One formal response is Ontario Bill 45, Making Healthier Choices Act, 2015, that amended the Health Protection and Promotion Act. Although requiring calorie labelling on menus (coming into effect on January 1, 2017), it could be further amended to include a provision that meals exceeding 800 calories[18] provide a reduced serving size option that is at least 33% lower in calories. This could be accomplished by reducing the serving size to meet that objective, either by removing certain items from the meal, or by reducing portions of all meal components. This approach does not require menu and ingredient reformulation, though some restaurants may choose to reformulate meals to bring them under the 800 calorie threshold. Restaurants without standard plate sizes – buffets, tapas, sushi and dim sum – would probably have to be exempted for logistical reasons[19]. Bloom (2010) provides the example of T.G.I. Friday's, a chain eatery in the United States, that launched a

[18] A more thorough review of the literature might determine a different threshold, but something around this one is likely suitable, given average person caloric requirements of 2000 calories (see discussion above)
[19] Note that there is a longer term question about eliminating buffets because of their contributions to overconsumption and waste generation (see Maguire, 2016).

"Right portion, right price menu" in 2007, where they served about two-thirds of an entrée for two-thirds the regular price. Bloom (2010, p. 130) states that this programme "proved so profitable that the chain made the promotion permanent a year later".

Animal feed

- **Expanding Suitable Feeds**
  Problems addressed: processing and restaurant waste, animal dietary inefficiencies

The federal Feeds Act and Regulations permit many kinds of plant, fish and animal processing by-products as animal feed (see schedule IV and V of the Feeds Regulations[20]), and there is a relatively well established infrastructure (from farm, processing and rendering facilities) for using such materials as feeds. Some of them (e.g., some animal by-products) will need to be progressively delisted to meet the conditions of the environmental protocols (above). Consumption will decline with animal population shifts and changes in the human diet, which will cause perturbations in the processing by-products markets.

The situation is more complex for plate waste from restaurants, institutions and households. Such materials are not named directly in the Feeds Regulations as they focus on single ingredient feeds and constituents. Plate waste is banned as a ruminant feed in Canada over fears of Bovine Spongiform Encephalopathy (BSE) or mad cow disease. Such feeds are typically only given to pigs, and only as a part of their diet. Belonging to the broad category of Recycled Food Products (RFPs), their use is now highly constrained. If sold, they must meet the conditions of the Feeds Regulations, highly unlikely because the regulations only grant minor variances in composition of the kind that plate waste cannot generally meet. They may be exempt from some of the regulations if they are donated to a single individual who uses them directly and does not redistribute. They must, however, be handled in a sanitary manner, which typically means refrigeration and then steaming to avoid disease spread. The rules effectively do not permit donation of plate waste from kitchens that also prepare meat, unless they are registered as feeds (CFIA, 2014a), a highly unlikely outcome given other conditions. Given the rules, and the infrastructure required to use plate waste on a widespread basis, opportunities as animal feed in the short-term are highly limited. Should Canada be sufficiently free of BSE in the medium term, some of the restrictions might be relaxed.

Human and animal inedibles directed to compost and industrial applications

- **Compost—backyard, mid-scale community, curbside**
  Problems addressed: Household, restaurant and retail waste, nutrient inefficiencies

[20] The Feeds Regulations can be found at: http://laws-lois.justice.gc.ca/eng/regulations/SOR-83-593/page-17.html

Given our hierarchy, food waste should first be composted in backyards, on-site at multi–unit residential buildings (MURBs) and at specific activity areas, such as farmers' markets and regular event locations. If this is not feasible, either because of the absence of facilities or the challenges of composting certain inedibles (e.g., bones and meat scraps in the presence of rodent and raccoon populations), then community (neighbourhood) composting is preferred, followed finally by residential and business pick up systems for centralized composting[21]. Backyard composting requires the least infrastructure and transport. Sites at MURBs and event locations are more complex to manage. Community composting requires more infrastructure and time to execute, and curbside pickup and centralized systems are the most expensive, involving the highest infrastructure costs and the most complex distribution. With anaerobic digestion in centralized collection systems, however, facilities have the greatest potential for methane capture which is part of their appeal for the dominant system in an environment of surplus accumulation (see O'Brien, 2013). However, all composting systems can generate poor quality product and high emissions, thereby making utilization problematic.

Numerous municipal programmes provide access to backyard composters and information, but are highly variable in the quality and effectiveness of other programmes, especially on-site composting in MURBs and event locations. In Ontario, municipalities were not required under the 2002 Waste Diversion Act[22] to collect food waste although most large municipalities do. The City of Toronto's Green Bin Program (GBP) is one of the largest organic waste diversion programmes in North America but until recently did not have the capacity to make compost from all its organic waste. Unfortunately, the procedure for building supporting organic waste processing facilities is long-term and cost prohibitive for many municipalities and businesses (Gooch et al., 2010). If actual diversion is lower than projected due to prevention and reuse resulting from measures proposed here, the current infrastructure may be adequate.

Unfortunately, most of the composted material in Toronto's programme is of such poor quality that it cannot be used for growing food (Seccombe, 2013). Equally significant, after the programme was put in place, the City reduced resources devoted to backyard composting (Vidoni, 2011) which, in our framework, is highly counterproductive. In contrast,

> the City of Edmonton has taken a unique approach to both solid waste and biosolids management at its composting facility, where 200,000 tonnes of organic municipal solid waste and 100,000 tonnes of biosolids are processed together to produce a compost that is sold to the agricultural, landscaping and land reclamation industries (Forkes, 2011, p. 65).

[21] Note that Life Cycle Analyses (LCAs) have not been conducted sufficiently to allow a full comparative assessment of these options (see Morris, Matthews, & Morawski, 2011).
[22] This act is being replaced by the Waste-free Ontario Act, which received Royal Assent in June 2016 but many measures will take several years to bring into force.

This suggests it is possible to design a curbside collection programme that can produce high quality compost.

In Ontario and other Canadian jurisdictions[23], community and mid-scale composting are essentially blocked by existing regulations. Community composting facilities would have to meet the regulatory and structural conditions set out for compost facility approval (OMOE, 2012) and obtain a certificate of approval as a waste disposal site. In Canada, this situation occurs because composting is still viewed primarily through the lens of waste diversion, rather than as an essential part of the nutrient cycle. In contrast, the five boroughs of New York City have some 200 sites, facilitated by the New York City Department of Sanitation's (DSNY) Bureau of Waste Prevention, Reuse, and Recycling (BWPRR) (Goldstein, 2013). There are many proposals to take a new approach, with one being considered at an urban farm in NW Toronto, but it is not yet clear what this will produce.

In the Ontario system, community composting sites should be exempted under the Environmental Protection Act, if they met the following conditions:

- The facility only receives residential food scraps and yard waste (with potentially very select addition of nitrogenous or carbonaceous material to obtain proper C:N ratios for composting quality). Québec allows up to 150m^3 of off-site waste to community sites at any time provided it does not contain any problematic material (e.g., meat, industrial waste) (Vidoni, 2011).
- Aerobic composting only.
- The operation composts less than 14 tonnes per week[24].
- In urban areas, minimum distances of 10 m[25] exist to the nearest property line, water body, road or pedestrian walkway.
- A leachate mitigation plan is in place.
- The facility meets the "A" compost quality standards.

Curbside programmes would also need significant modification to create useable compost. Although participation rates are high, there is debate about how much household organic waste is actually put in the bins, so improving that rate is important. By some accounts, one-third of current garbage is still organic waste (Alfred, 2013). There are a number of issues associated with the current programme in Toronto. The use of plastic bags increases participation but decreases quality. The bins are poorly designed to prevent raccoons. Some percentage of the collected material does not get composted at all, in part because of a lack of processing facilities. Much of the composting is anaerobic which generally reduces nutrient quality in the residue that

[23] The federal government typically has jurisdiction only over hazardous waste, while non-hazardous waste falls under provincial jurisdiction. See Lucas and Cotton (2013).
[24] Vidoni (2011), based on US rules. Note this is also below the MOECC threshold for requiring an EAA.
[25] The MOECC states there should be a minimum of 100m between all buildings, processing and storage areas, access roads, the nearest residence, school, place of worship, hospital, and any other public institution, bodies of water. Such distances are not viable in urban areas.

is subsequently aerobically composted in windrows. Efforts continue to use the methane generated for electricity production. Given the new provincial categorization scheme (OMOE, 2012a), Toronto compost should at least meet "A" compost requirements.

- **Increase tipping fees**
  Problem addressed: all wastes destined for landfill

"From a retailer's perspective, if you could get your dumpster to get hauled for half the price to go to landfill than to a compost facility, it's an easy choice. Their business is food, they need to make money to keep their costs down." (Policy analyst, Environmental Commissioner of Ontario, personal communication, February 25, 2011)

Municipalities can use by-laws to set user and tipping fees. There is some debate about the level at which such fees would encourage alternative behaviour and the question is affected by the degree to which alternative approaches exist, with suitable infrastructure and support. As part of a long-term transition strategy, increasing fees is a first step to more significant changes down the road. Some evidence from local Canadian jurisdictions suggests fees over $100/tonne are required to get significant diversion (Anderson, 2014).

- **Food waste and provisions of the Waste-free Ontario Act**
  Problem addressed: All

Compared to the 2002 Waste Diversion Act, the new Waste-free Ontario Act places greater emphasis on resource recovery, the circular economy, waste reduction and producer responsibility for waste. Up to this point under the 2002 Act, organic waste did not receive substantial attention, although many municipalities have been running green bin programmes. However, many provisions of the new legislation will take time to put into force and the language of the Act is broad and enabling, with only one overt reference applicable to food waste. Under 69(2), regulations can be adopted that,

"(a) must allow for the material or part of the material to be:
(i) reused,
(ii) used in the making of new products, packaging or other things, or
(iii) used as a nutrient for improving the quality of soil, agriculture or landscaping;"[26]

The government is responsible for developing a strategy entitled Strategy for a Waste-Free Ontario: Building the Circular Economy, with goals and reporting on implementation. The consultation document (MOECC, 2015) of the same title indicates that the goals of the final strategy will include zero waste and zero GHG emissions associated with waste. There would be

[26] Waste-free Ontario Act, http://www.ontla.on.ca/bills/bills-files/41_Parliament/Session1/b151ra.pdf, p. 7

an organics action plan as part of the wider implementation agenda. It would address the entire supply chain, and build upon existing initiatives, with development and rollout through 2018. The Strategy would also consider disposal bans. While encouraging, ensuring that the details of the regulations support the initiatives set out here is the challenge.

- **Improving deadstock handling**
  Problem addressed: Farm production waste

In natural systems, dead animals become food for scavenger and decomposer organisms, representing a more closed nutrient loop than exists on many modern farm operations. Admittedly, recreating such conditions is difficult on smaller farms proximate to settled areas, though perhaps still feasible in extensive rangeland scenarios.

Deadstock is regulated provincially and the rules have shifted significantly since the BSE crisis of the early 2000s. In Ontario, the Nutrient Management Act (2002) and regulations largely govern disposal of animals that die on-farm. The shift was designed to provide greater environmental protection and separation of dead from live animals. For animals that die off-farm, the regulations of the Food Quality and Safety Act (FQSA), 2001 are in effect. They are designed to ensure that deadstock does not end up in the food chain[27].

On-farm, there are numerous disposal options, including: "burial, incineration, composting, disposal vessels, collection by a licensed collector, anaerobic digestion, delivery to a waste disposal site approved under the Environmental Protection Act, delivery to a disposal facility as defined under the FSQA, delivery to a licensed veterinarian for post mortem and disposal."[28] From an agroecological perspective, composting on-site is the most desirable option if there is a suitable land base for cycling the nutrients, followed by on-site anaerobic digestion if the digester collects methane and the residue can be properly distributed as nutrients. Admittedly, there are challenges for on-site composting though OMAFRA believes it is a very viable option and does provide guidance[29]. Licensed collectors can also transport to centralized composting sites, though this is less favoured because of the transport and the challenges with redistribution of compost. They may also take deadstock to rendering facilities, though opportunities for re-using material from ruminants have declined significantly since BSE[30]. In an emergency situation (e.g., barn fire, natural disaster), the regulations may be waived and other options approved. On-site composting has only been permitted since 1996, so it is probably not the favoured option, and if a farm does not already have a suitable composting system, the installation costs can be significant. But fees charged by firms for deadstock disposal have

---

[27] OMAFRA's deadstock regulations: http://www.omafra.gov.on.ca/english/nm/regs/deadstock/summary.htm
[28] OMAFRA's deadstock regulations: http://www.omafra.gov.on.ca/english/nm/regs/deadstock/summary.htm.
[29] Two OMAFRA factsheets on different approaches to on-farm composting can be found at: http://www.omafra.gov.on.ca/english/engineer/facts/10-063.htm, and http://www.omafra.gov.on.ca/english/engineer/facts/09-031.htm
[30] Those parts of the animal deemed at risk of carrying BSE must be removed and most of that is landfilled. The volumes have increased since the enhanced feed ban went into effect in 2007 (Koch, 2009)

increased (from first paying a fee to the farmer, to free pickup, to a government subsidized fee for certain stock, to a significant fee without subsidy, see Sun Media, 2009), perhaps encouraging more on-site burial, but not necessarily composting (Crosby, 2009). Canadian renderers report a 50% decline in deadstock material picked up since the implementation of service charges (Koch, 2009), but some environmental organizations are opposed to on-site composting for fear of negative water quality impacts (Vandusen, 2010).

For animals that die off-farm, on-site composting at other locations in the supply chain is not permitted.

> The FSQA regulation provides for centralized composting of deadstock. It sets out the application, siting, facility and operational standards and requirements for those centralized deadstock composting facilities. The facility and operational requirements provide for various composting and curing methods as well as for composting pads made of different materials. The regulation establishes turning, temperature and substrate standards. Compost that is derived from deadstock and that has been composted in accordance with the regulation may only be sold if it meets all of the prescribed standards for finished compost. Material that fails to meet the requirements may be re-composted or disposed of at an approved waste disposal site depending on the regulatory defect(s). The regulation specifies who may transport material, other than finished compost, from a composting facility.[31]

The current policy approach, as with many aspects of agriculture, is to present a buffet of options from which private landowners can choose. The state does not necessarily encourage the most desirable options. From a nutrient cycling perspective, this is suboptimal. The priorities should be on-site composting for farmers wherever feasible and centralized composting facilities for other segments of the food chain. For farmers, a big problem is assessing the hazards of composting on their farms, and then designing and paying for the right kind of composting approach. Providing extension and consulting services to design and executive an optimal strategy is paramount. Regarding, centralized facilities, many regions of Canada do not have such facilities, or enough disposal and rendering companies to support a facility or handle BSE or PED hazardous material for landfilling. The provincial governments should create funding pools for deadstock infrastructure that are analogous to the programmes that partly subsidize human waste management.

- **Easing transitions of the rendering industry**
  Problem addressed: Processing waste and resource recovery

[31] OMAFRA's deadstock regulations: http://www.omafra.gov.on.ca/english/nm/regs/deadstock/summary.htm.

Given how much of an animal is not edible for humans, and the challenges of deadstock, the rendering industry plays a critical role in a food waste hierarchy. The sector has been challenged since the discovery of BSE in Canada in 2003, partly by the expense of new regulations to minimize the spread, and partly by shifts in markets. But equally significant, the sector has a major interest in high levels of animal product consumption and high animal densities, both conditions that have to shift for reasons of sustainability and health. So, the challenge is locating an appropriate and viable place for the sector as wider shifts in consumption and production take place.

The federal government should finance a third party assessment of transition options for the rendering industry, consistent with this paper, under Growing Forward III contribution agreements.

Sewage sludge and humanure application to land to close nutrient and energy loops

Sewage treatment is a highly complex topic, worthy of a paper of its own, but here we provide some summary thoughts on transitional strategies that fit within the themes of this article.

- **Separating sewers in established communities**
  Problem addressed: nutrient recovery

Many neighbourhoods in Canadian cities were built with combined sewer outflows (CSOs), rather than separate piping for household waste water and storm runoff. For example, in the older parts of Scarborough in Toronto, most houses were built with CSOs, and from the 1960s, new subdivisions were constructed with separate systems. By 2008, approximately 35% of the area had combined sewers, 45% had partially separated sewers[32] and only 20% was separated[33]. Compounding this problem, many commercial facilities also have CSOs. Commercial and residential downspout disconnection programmes have helped reduce, at a relatively low cost, the number of partially separated systems. However, fully separated systems are expensive to create from CSOs, and progress has been slow, dependent particularly on capital budgets. In Toronto's case, the municipal government has a 25-year Master Plan to improve stormwater management and sewer systems.

Continuing the process of pipe separation of industrial from residential and elimination of contaminants and of residential CSOs are critical strategies.

Substitution initiatives

[32] In a partially separated system, street stormwater is carried off separately, but household stormwater ends up in the household waste water pipes.
[33] Public education materials from a 2008 public consultation on sewage separation in Scarborough sheds light on this,
http://www1.toronto.ca/city_of_toronto/policy_planning_finance__administration/public_consultation_unit/toronto_water/scarborough_waterfront/files/pdf/2008-06-16_posterboards.pdf

This phase involves new organizational arrangements, the substitution of processes and practices, and brings alternative / niche activity into the dominant flow of change. What new structures can be put in place for resource planning? What regulatory instruments might move firms from efficiency measures to this stage?

Edible food for direct human consumption at minimum resource expenditure

- **Protocols for resource efficient production**
  Problems addressed: solar, metabolic and input inefficiencies

In other work, MacRae and colleagues (MacRae et al., 1990, 1990a; 1993, 2009, 2010, 2012) have set out the strategies for altering food production and processing to significantly reduce resource consumption; therefore, these dimensions will not be addressed here to any extent except to highlight the need for mandatory production protocols that reflect such progressive redesign of production and processing. Many voluntary standards currently exist (e.g., organic, natural, animal welfare, integrated pest management), but none is mandatory and only a few are backed by state regulation through the Canadian Agricultural Products Act (CAPA) and in some cases provincial regulation (see rules governing, for example, organic in British Columbia and Québec). The existence of such protocols would facilitate some of the proposals set out here.

- **Grading changes**
  Problems addressed: Farm, processor and retailer waste

Grades were originally created and regulated to help stream products to different end uses, based on the "quality" parameters identified by the grade. However, over time, the grade structures have been changed and simplified. In many foods, different varieties are now grown under contract for specific end uses, that is, the grade becomes less meaningful for determining end use designation. As discussed earlier, retailers impose their own quality standards that exceed regulated grades. However, the consequence is that the cosmetic perfection imposed by retailers results in higher levels of waste.

The removal of grading standards for fresh market fruits and vegetables (excluding potatoes) by OMAFRA [34] presents a unique opportunity to explore the relationship between grading standards and food waste. Earlier studies postulated that grading standards caused food waste by preventing producers from selling subgrade produce to secondary processing markets. Our interviews suggest, however, that the removal of grade standards has not changed supply chain behaviour because retailer standards are higher than state ones.

[34] Revoking Reg. 378 of the Farm Products Sales and Grades Act.

Instead of having government regulate a floor standard for food quality, it should instead impose a ceiling standard that retailers cannot surpass. The standard should be designed explicitly to balance quality against waste minimization. For instance, cucumbers that are more than "moderately curved" and are longer than four inches should be included in Canada grade No. 2 cucumbers, while under the previous approach (prior to grade elimination in 2011) they would have been excluded because of the curvature. Such changes would help producers either enter the existing market or create a niche market for those foods that are misshapen and discoloured but taste just as good if not better and are high in quality despite the way they may look. Producers can find innovative ways to market the different kinds of products. There are consumers interested in buying foods that do not fit the typical perfectly displayed appearances and actually look for good taste. Retailers in France, Québec, Ontario, Alberta and the U.S. have already cottoned on to consumer interest and are marketing "ugly" and "misfit" produce (Cliff, 2014; Galliot, 2014). Loblaw's is slowly taking its new program national (Liu, 2016). Although popular with many consumers, not all these programs are well designed to reduce waste, in that some divert food from processing to the fresh market that is not actually unsellable grade-outs coming directly from farmers (Perreault, 2015). Consequently, in the Ontario case, to assure substantive waste reduction, new grade standards for fruits and vegetables will need to be introduced under the Farm Product Sales and Grades Act to replace the earlier *Regulation 378* that was revoked.

- **Regulating varieties for processing**
  Problem addressed: Farm and processor waste

The choice of variety can have a significant impact on waste generation. Perhaps the most emblematic example is the Russet Burbank potato, long used in French fries by the fast food industry. It is a long season variety and historically very demanding of moisture and nutrients, resulting often in significant irrigation, pesticide and fertilizer use. Only about 50% of the potato is used during French fry production due to the imposed standards of the industry and there can also be significant field culling. All these realities have encouraged the fast food industry to explore other varietal options (Escober, 2010). Under the Ontario Farm Products Sales and Grades Act and the Potato Regulations under the Farm Products Marketing Act, it would appear that the authority exists to determine what varieties can be processed and under what conditions[35]. A set of varietal regulations should be developed that favours those with lower resource requirements and waste factors.

Can current legislation forbid other contract provisions that contribute to food waste? The Farm Products Marketing Act appears to offer such a possibility. The Act provides "for the control and regulation in any or all aspects of the producing and marketing within Ontario of

[35] See clause 19, Ontario Regulation 247/99**,** http://www.search.e-laws.gov.on.ca/en/isysquery/bd27fbf1-e226-45a6-9c15-7cdff0eae1c1/9/doc/?search=browseStatutes&context=#hit1

farm products including the prohibition of such producing or marketing in whole or in part."[36] With suitable supporting regulations, the Commission created by the Act could govern contracts in this way.

- **Requiring sustainable procurement**
  Problems addressed: Solar, metabolic, land use, water and nutrient inefficiencies, farm waste

Although many firms have sustainability goals, these are often disconnected from food buying practices. There are a number of reasons for this related to internal firm dynamics (Cooke, Stanley, Carter, & Whitehead, 2014), but one part of the problem is the lack of authentication of sustainability claims. Typically, procurement programmes need robust authentication to assure buyers and consumers. As part of resource efficient production protocols (see above), it would also be desirable to establish waste minimization certification programmes, with elements of the protocol designed to alter supply chain behaviour. There are examples of solid waste certification programmes offered on a voluntary basis for commercial and institutional properties (e.g., the Recycling Council of Ontario's 3R Certified[37]) that could be adapted. A certification mark under the federal Trade-marks Act[38] could be established to support the branding of the project. Ideally, such measures would also be supported by provinces for goods traded within their province, perhaps similar to the programme of the Conseil des appellations réservées et des termes valorisants (CARTV) in Québec[39]. As part of this, increased supplier-retailer collaboration can be a significant benefit. A WRAP U.K. project found noticeable waste reductions in all eight case studies as a result of increasing supplier-retailer collaboration (Tupper & Whitehead, 2011). Such collaborations help firms meet their targets under the Courthauld Commitment, a U.K. grocery sector voluntary plan to reduce waste in the food supply chain.

- **Advertising**
  Problems addressed: Luxus consumption

Luxus consumption must be reduced, for reasons of population health and food waste reduction. Many ads depict excessive portion sizes and eating, binging and addictive reactions to foods, and dreaming about eating. Food advertisements do increase consumption (Harris, Bargh, & Brownell, 2009). Chou, Rashad, and Grossman (2008) estimated a ban on fast food ads would reduce the number of overweight children between 3 and 11 by 18% and overweight adolescents between 12 and 18 by 14%. Québec has for many years banned food advertising targeted to

[36] The Act can be found at: http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90f09_e.htm
[37] Programme details at: http://3rcertified.ca/
[38] This is based on our reading of Buckingham (2014).
[39] Details at: http://www.cartv.gouv.qc.ca/en

children under 12. One study found that Francophone families are primarily affected by the ban. Francophone young adults in Québec were 38% less likely to purchase fast food than their Ontario counterparts (Dhar & Baylis, 2011).

Television and print ads outside of Québec are weakly regulated in Canada, although the Minister of Health recently announced a process to tighten the rules around advertising to children (Lunn & Harris, 2016). There is no longer a mandatory requirement for pre-market screening of print and internet ads. Internet and social media are more difficult to regulate at this stage, although still covered by the general requirements of the Food and Drugs Act (FDA) and Canadian Consumer Packaging and Labeling Act (CCPLA). Other than the general fraud provisions of federal legislation and certain specified requirements[40], guidance is voluntary, through the Canadian Association of Broadcasters' Code of Ethics[41] and the Canadian Code of Advertising Standards[42].

We propose that food ads no longer show people eating, that only the product be shown. Use of cartoon characters would also be forbidden. Consequently, new regulations in the Food and Drugs Act (FDA) and the Consumer Packaging and Labeling Act (CPLA) will be required to prevent depictions of food being consumed. This should be undertaken as part of a broader initiative to bring many voluntary measures in the two codes into regulation. Clause 14 of the Canadian Code of Advertising Standards provides a framework for removing such depictions but additional language is required.

- **Design standards for waste minimization**
  Problems addressed: Processor, retail and restaurant waste and resource inefficiencies, animal feed, food donation

Some Canadian cities have now instituted green standards for residential and non-residential building siting, commissioning, design and construction. Toronto adopted such a standard in 2009.

> The Green Standard is a set of performance measures that promote sustainable development.... The Toronto Green Standard is a key element of the City's Climate Change Action Plan, an aggressive environmental framework aimed at reducing Toronto's greenhouse gas emissions by 80 per cent by 2050...[its authority flows from].... Official Plan Amendment 66 that enables the City to address

[40] See CFIA's guide to advertising requirements for industry, http://www.inspection.gc.ca/food/labelling/food-labelling-for-industry/advertising-requirements/eng/1388685207800/1388685209565
[41] Available at: http://www.cab-acr.ca/english/social/codes/ethics.shtm
[42] Available at: http://www.adstandards.com/en/Standards/canCodeOfAdStandards.aspx

> sustainable design elements on the exterior of a building as provided for with new powers for Site Plan Control in the City of Toronto Act.[43]

The standards do not currently contain explicit reference to building design to minimize waste generation, however, the energy efficiency measures are pertinent to this discussion (e.g., efficient heating and cooling processes). The solid waste dimensions of the standard can be modified to include:

- facilities for depacking loads and recuperating useable foods
- kitchens that permit use of soon to expire fresh foods in preparation of deli foods
- facilities for chilling foods that cannot be sold for human consumption but could be donated to pig producers or diverted for industrial purposes
- restaurant designs that permit easy source separation collection and storage (Maguire, 2016)

In Toronto's case, the green standard has mandatory (tier 1) and voluntary (tier 2) provisions. Such measures proposed here could start as tier 2 measures and later, once tested and refined, become tier 1 measures.

A further step would be to regulate the actual design of store shelves and display areas. Store designs encourage waste in 2 specific ways (see Ontario Public Interest Research Group, 1990). First, they encourage shoppers to buy more than they intended (70% of purchases for the average shopper are impulse buys). Second, the typical store is set up so that fresh fruits and vegetables are the first items to be purchased. This conveys abundance and encourages more purchasing, but it also means the most perishable items have to be continuously shifted in the shopping cart to avoid damage. This reduces their refrigerator life and generates more waste. From a waste reduction perspective, it makes much more sense if the produce section is the last stop before the checkout. It is unlikely that stores will voluntary change the flow of customers, so this should be regulated by municipalities as part of green design standards.

Animal feed

- **Environmental protocols**
  Problems addressed: Solar, metabolic, land use, water and farm input inefficiencies, animal populations

Implementing environmental protocols includes triggering evolutionary changes to animal populations and animal feeding regimes (see discussion above under Human Edibles). These

[43] Appendix D of Urban Design standards for mid-rise buildings in Toronto, http://www1.toronto.ca/City%20Of%20Toronto/City%20Planning/Urban%20Design/Mid-rise/midrise-AppendixD.pdf

shifts can progressively address many of the resource inefficiencies discussed above. In future work, we will be exploring how the architecture of Growing Forward III, the federal agricultural policy framework, can be used to ensure creation and adoption of such protocols.

- **Plate waste regulatory changes**
  Problems addressed: Feed efficiencies, restaurant and institutional waste

There is a significant requirement to build strategic infrastructure that links plate waste to swine producers. Hogs are by nature scavenger animals (Honeyman, 2005), but the centralized nature of much swine production, including the feeding regimes, makes it unlikely that large hog operations will be interested in plate waste. The challenge then is to find small-to-medium sized operators who will find plate waste a viable feed. The best opportunities may lie with marketing co-operatives and private aggregators. Similarly, it makes sense to aggregate plate waste suppliers, focusing on large institutional food service in a single or clustered location. Ideally, providers and users are in proximity which suggests the need to focus on large institutional food service in centres adjacent to pig production areas. However, this will not likely be feasible until rules restricting meat plate waste are relaxed. Then, it would be possible to establish collection systems without segregation. Refrigeration of waste is a critical feature as is steaming, but the latter could be carried out by intermediaries if it was not feasible for the co-op or aggregator to establish such a facility. To test the viability of such systems, provincial governments could provide support with capital grants for the establishment of suitable facilities.

Human and animal inedibles for compost and industrial applications

- **Curbside collection programmes: residences, MURBs and commercial establishments**
  Problems addressed: Retail, restaurant and household waste

Municipal planning departments should require new multi-residential buildings to have organic waste collection infrastructure incorporated into their design. The hope is that such initiatives will be mandated to municipalities by the Ministry of the Environment and Climate Change (MOECC) as part of the organic waste action plan under the new Waste-free Ontario Act.

- **Landfill ban**
  Problems addressed: All organic waste designated for landfill

In Ontario, municipal and/or local governments can regulate waste management and recycling activities through their by-laws, including setting in place landfill bans (restricting what materials can be landfilled)[44]. The new provincial Waste-free Ontario Act also sets the stage, within the Strategy required by the province, to enact disposal bans.

A number of other jurisdictions have undertaken such initiatives. The government of Nova Scotia enacted a landfill ban for all organic waste in 1998 (Friesen, 2000), and currently, a negligible amount of organic waste is sent to the landfills. This ban led to further implementation of the compost and biogas industries; however, Nova Scotia is currently struggling to send its organic waste to such facilities because the infrastructure was not set up efficiently when the ban was enacted. The Regional District of Nanaimo has a ban on commercial organic waste[45]. Metro Vancouver brought in an organic disposal ban on January 1, 2015, with an effective date of July 1. The staff has noticed an increase in depacking services, organic pick up services, and a 10% improvement on tonnage going through local composting facilities. Restaurant and institutional food service source separation systems have increased dramatically. Although enforcement is an ongoing challenge, and fines are still being levied, organics are down from 36 to 28% of the waste stream (Marr, 2016). Massachusetts implemented a ban in 2014, and Vermont has set one to begin in 2020 (Specht, 2013).

Ontario would have a difficult time implementing a province-ban in the short term. However, as a substitution stage strategy, many changes to waste reduction infrastructure and management will have already been implemented before a landfill ban is enacted, making it more feasible.

Sewage sludge and humanure application to land to close nutrient and energy loops

- **Nutrient removal technologies**
  Problems addressed: Nutrient inefficiencies and recovery

Numerous technologies have been used, and others are under development, to remove nutrients from sewage sludge and urine and make them available to the fertilizer industry. For example, "even among facilities not currently regulated for specific numeric criteria, many have the capacity to remove as much as 20 to 50 percent of their current nitrogen load through minor process changes that require little capital investment." (The Johnson Foundation, 2014, p. 8)

This approach avoids the problems associated with spreading biosolids, and consequently is an intermediate stage strategy. Struvite is one of the best developed products, rich in P, Mg, and N. Precipitation, thermal treatment, crystallization, separation and wet chemical processes have been used to extract nutrients, in research and/or in practice (Water Environment Research Foundation, 2011). Some 30 nutrient recovery processes have been identified (Cordell, Rosemarin, Schröder, & Smit, 2011) and many others are at the assessment stage with questions such as: how efficiently does the process extract nutrients; at what quality, financial and resource cost; and what kinds of revenues they can generate to balance against costs, what kinds of

[44] For details on how waste is regulated in Ontario, see https://www.rco.on.ca/how_waste_is_regulated
[45] The by-law is available at: http://www.rdn.bc.ca/cms/wpattachments/wpID98atID2047.pdf

regulatory environments might favour recovery? Public utilities will need support to test and implement these systems.

- **Small scale/decentralized sanitation systems in smaller new settlements**
  Problems addressed: Nutrient inefficiencies and recovery

In new small settlements, some of which are deliberately positioned as eco-village designs, there are opportunities to rethink the traditional approach to sanitation systems. Ranging from individual household onsite systems to community-level designs, many have proven to be feasible at lower cost, and may better serve remote or low-density populations. Many also are able to dispose of treated or untreated excreta/wastewater on land because humanure is not contaminated with industrial pollutants (Cordell et al., 2011).

- **Change code rules to permit more composting toilets and solid (rather than wet) sanitation systems**
  Problems addressed: Nutrient inefficiencies and recovery

Austin Texas may be one of the few cities in North America that permits composting toilets (Price, 2009). There are substantial issues with dispersion of the compost. However, the Ontario Building Code appears to permit them under Class 1 of its five classes of sanitary sewage and disposal: a chemical toilet, an incineration toilet, a recirculating toilet, a self-contained portable toilet, and all forms of privy including a portable privy, an earth pit privy, a pail privy, a vault privy, and a composting toilet system, all of which can receive only human waste.

Redesign initiatives

Edible food for direct human consumption at minimum resource expenditure, animal feed, and human and animal inedibles for composting and industrial applications

- **Demand-supply Coordination**
  Problems addressed: All

This phase involves the redesign of food production, distribution and processing for waste minimization through the lens of demand-supply coordination. A system built on demand-supply co-ordination shapes production processes to meet consumption requirements that improve the health of the population. It takes more of a “feed the family well, trade the leftovers” approach (Kneen, 1992).

On the demand side, MacRae and colleagues have set out strategies for encouraging more optimal food consumption (Toronto Food Policy Council, 1994; 1996; 1997; MacRae et al., 2012a). There have also been a few studies examining demand-supply management scenarios with optimal health a significant consideration (see for example, Desjardins, MacRae, & Schumilas, 2010; Ostry & Morrison, 2013; a review in MacRae, 2014), but these have not proposed mechanisms and tasks for executing such a process.

Building on Sweezy's theories of capitalist surplus, O'Brien (2013, p. 202) argues that,

> capitalist societies are permanently scarred in one of two ways: either by a crisis of excess – where there are simply too many goods on the market and the restricted consumption of the masses prevents their sale – or because the productive forces themselves are left to stagnate in order to offset precisely [a] crisis of underconsumption.

What is lacking is the mandate, structural linkages and governance across the food system to substantially address this reality and to reduce waste in all its forms and create greater resource efficiency. One possible solution is widespread demand-supply coordination (DSC) at a macro scale, broadly positioned within the arena of Integrated Resource Planning. DSC, if properly designed, could help reduce luxus consumption by changing the mix of products the food system provides, re-orient production to resource efficient approaches, reduce the distance food travels, and create greater food utilization along the supply chain.

DSC is not a popular concept in a food system run largely by private interests with relatively minimal state intervention. Private firms view it as interference in market function and, in countries dominated by oligopoly capitalism, the state is reluctant to intervene on the food demand side of the ledger, viewing its function primarily as management of supply (see Hedley, 2006). For many, it is linked to the earlier failures of central planning, and certainly the lessons of those failures must be reflected in a more reflexive and flexible design for demand-supply coordination (Voß, Smith, & Grin, 2009).

Clearly, there are pros and cons to DSC for food system actors. For producers, long term security is generally more favourable than short term, so designing such incentives in the system is an important consideration (Gille, 2013). In other words, can demand-supply coordination create a financial security that does not currently exist through more volatile or unreliable risk management instruments, such as production insurance and futures markets? It also means shifting production and marketing based on management considerations beyond the farm, something that challenges a traditional view of farming as private property rights and management. For manufacturers and retailers, it means shifting product options to comply with optimal nourishment requirements and volumes. For consumers, it means higher availability of some healthy goods (and sometimes at a lower price to encourage consumption) but lower availability of less nourishing items (and potentially at a higher price to discourage consumption). It also suggests significant changes in shopping behaviours and potentially shifts in the type and locations of food retail outlets[46]. All this challenges traditional interpretations of consumer choice.

In Canada, the supply-managed commodities are currently the most visible example of some degree of supply-demand co-ordination. The current approach lacks a focus on optimal nourishment, being primarily designed to create orderly marketing and stable pricing and returns for producers. These are all important objectives, but a more ideal system would look at optimal consumption to generate better health outcomes, rather than just focusing on current demand. This is a significant issue because all the supply managed commodities are animal products, and in general the population is overconsuming them for optimal health. Learning from the energy experience in Ontario (Winfield & MacWhirter, 2013), it may be unwise to just inject demand management into supply planning, suggesting the need for officially broader mandates and different institutional arrangements than exist with supply management.

What ideally does a DSC approach look like? A key part of data gathering is garnering a fuller understanding of what optimal consumption looks like on a regional population basis and how far away from that scenario a region is at any given time. Currently, we have only national and some regional food consumption estimates (see, for example, Desjardins et al., 2010; Ostry & Morrison, 2013). What percentage can be feasibly supplied by the region, given existing biophysical and economic constraints? In general, optimal diet means consuming more whole grains and pulses, less animal product and, more fruits and vegetables (especially coloured vegetables), fewer refined oils (away from soy, corn and palm oil and more toward olive, flax and canola), less sugar, and fewer processed beverages. Fish is a desirable part of the diet, but the state of the international and domestic fisheries suggests dietary requirements cannot be optimized.

What initiatives are required to better align production and consumption, and what supports can be provided to food chain actors to assist the transition? This effort to align production and consumption is also set within the context of wider land use planning issues such as agricultural land protection and minimizing losses to other uses[47]. There are significant public and private resources dedicated to projecting supply of key commodities, but Canada does not currently have good public data on crop rotations or regional linkages between crop and animal production. Equally unknown is the amount of high quality land producing foods of low utility for humans or with suboptimal production because land quality is compromised by conventional practices. These challenges are indicative of the kinds of new data collection requirements to make DSC work.

Mechanisms are required for setting prices and shifting agricultural production to align with regional priorities. Price setting is also required to minimize waste generating impacts of low priced imports that have historically created higher losses in domestic markets (e.g., cheap apple juice concentrate from China, see Proulx, 2014). Currently, price setting is only undertaken by a limited number of commodity marketing boards, so wider processes and instruments are

[46] Some of our future work will address this issue of urban planning, design and transportation.
[47] There are significant land protection and land tenure issues that we do not discuss in any detail in this paper.

required (see below). However, the federal government has significantly intervened in supply and demand dynamics in the past. During WWII, a wide range of structures and instruments were employed to shift production and consumption. These interventions were realized because the government recognized that the price system would not be capable of properly allocating resources amongst competing needs (Britnell & Fowke, 1962; Mosby, 2014).

Although an argument can be mounted that price failure is also widespread in the modern food system (on externalities and price failures, see Pretty, Brett, Gee, Hine, Mason, Morison et al., 2000; Tegtmeier & Duffy, 2004), the challenge is to identify tools that will have some acceptability in a traditional free market environment. Significant state intervention is more feasible when farmers rely extensively on state assets, for example, when leasing government land, the conditions of production can be written into the leases. The U.S. federal Cuyahoga Park in Ohio is one example of an approach that could possibly be replicated in the new national urban park in the Rouge Valley on the east side of Toronto (Dempsey, 2013).

Outside of such contexts, the interventions must encourage producers to shift volumes of individual commodities, but also between commodity categories. Such shifts must be undertaken in ways that respect environmental requirements related to crop rotations, animal densities and alignment of crop requirements with soil capabilities. A possible approach is to build on the Canadian tradition of single desk selling but organize it around common crop and rotational groupings rather than individual commodities: small fruit and melons; pome fruits; stone fruits; field crops and potatoes; vegetables; beef; pork; goats; and sheep. The supply-managed commodities – dairy, eggs, chicken, turkeys – would have their mandates modified (see below). Recent shifts in farm organizations – for example combining corn, soybean and wheat grower organizations in Ontario – suggest some sympathy for this approach. The single desk sellers would require that farmers use growing and processing protocols that meet resource efficiency requirements (discussed in earlier sections). These protocols would also regulate production for energy and plastics crops.

Specialty production (including grapes since they are primarily produced for alcohol in Canada) would not be included in DSC. The input sectors would also be largely excluded from the process, but would have to adapt to adjustments imposed by DSC, for example changes to seed production, hatcheries, breeding stock and genetics.

A possible model for prices setting is that used in the energy sector. The single desk sellers fix a minimum price for domestic suppliers and then everyone who wants to participate organizes to produce and deliver for that price[48]. This price reflects some cost internalization associated with environmental improvements and waste minimization. Those not wishing to participate can sell to international markets. This runs contrary to the previous iteration of the Canadian Wheat Board (CWB), but could retain some of its elements including price pooling. The price setting is designed to reflect both consumption and production requirements with health the ultimate purpose.

[48] Note that regulatory instruments to give authority to such approaches have been used in the past (see Britnell & Fowke, 1962).

In general, then, given current consumption patterns, animal products would be higher priced, fruits and vegetables lower. There would need to be internal transfers to balance returns to producers, so effectively price pooling across single desk sellers. This kind of price setting would violate current trade arrangements so this assumes that they have been redesigned (see MacRae, 2014). In this model, the single desk sellers do not take possession or own distribution infrastructure; rather, they create virtual market places where buyers and sellers meet, conclude their deals and set up the delivery process. All the deals go through their infrastructure which then allows for monitoring and research. The set price assumes a particular level of waste, one that declines over time. As such, it creates an incentive to do at least as well as the projected level so that net margins improve relative to the average. At this stage, many waste costs have been internalized and many technological efficiencies generated (see Efficiency and Substitution stage proposals).

This approach is loosely based on the Sacolão markets of Brasil. In this model, a variant on the ration shop approach, the state sets the terms of trade, including prices and then allows the private sector to make arrangements to assure their profitability within the parameters established by the state. The state owns and maintains the markets, but does not subsidize directly their operation. In this case, the market place is virtual. Many virtual markets already exist and supply managed commodities use sophisticated modelling to project supply and demand, so by the time this is implemented, the software should be well developed. Regional requirements could be modelled using Agent-based Modeling (ABM-GIS) (see Ghaffari, Bunch, MacRae, & Zhao, 2015). The regulations ensure that for covered domestic products, sellers must sell through the system. The price provides long term security.

Effective demand–supply management includes animal feed. Given changes to animal populations and feeds discussed in the efficiency and substitution phases, there would be significant shifts to hay and pasture acreage, though the animal reductions would make the shifts somewhat less significant. The orderly marketing boards would have to manage quota reductions[49] and coordinate the shift out of animal production to other kinds of production, and this would have to include coordinating the reduction in feedgrains.

In the ideal implementation of the hierarchy, the following would happen (Table 3). Significant work needs to be done to model the transition and transitional impacts of such changes, in combination with significant reductions in animal populations.

Consistent with the proposed waste hierarchy, there needs to be some coordination between human, animal and industrial applications. While human and animal crop uses would be governed by the single desk sellers (including crop by product sales for animal feed), industrial uses would not. In Canada, the production of biomaterials includes soy-based foam, composite building materials using agricultural fibres, and bioplastics in vehicle interiors[50]. However, industrial use contracts and sales would have to be registered with the single desk sellers for

[49] Proposals by opponents of supply management on how to do this are not suitable for a variety of reasons.
[50] From AAFC's categorization of bioproducts at: http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/bioproducts/types-of-bioproducts/?id=1370636403932

information purposes. Non-food uses currently account for about seven percent of the value of agricultural production, excluding production for agricultural inputs (seeds, breeding stock, etc.) (Agriculture and Agri-food Canada, 2012). Unfortunately, it is not clear how this relates to land use patterns[51].

MacRae et al. (2010) set out the requirements for resource efficient biofuel production on organic farms and similar conditions would need to be elaborated for most industrial applications. Many applications are not well suited to a resource efficiency scenario, including human grain–based ethanol (too much energy expended to produce it, unless the grain is not suited to human and animal feed, usually a small proportion of production), and sugar beets as a feedstock for biochemicals. More resource efficient is lignocellosic residues for fermentable sugars and gasification, a precursor for fuel and biochemicals (plastics, solvents, adhesives, paints, dyes, pigments and inks). Unfortunately, most current bio-based plastics and chemicals rely on first generation feedstocks, mainly sugar, starch, plant oil and rubber (Carus & Dammer, 2013). Second generation feedstocks are more suitable (short rotation coppice of popular, willow, miscanthus) and fit with the MacRae et al. (2010) scenario, but capital costs and the challenges of enzymes (especially non-GMO) are currently significant. Third generation feedstocks, such as algae in closed vessel processes, are on the horizon.

Feedstocks need be grown on lands unsuitable to food crops, typically Class 5-7 land that does not qualify for specialty production, with attention given to competition with hay and pasture for animal feed. As animal production declines, considerable acreage may actually be freed up for industrial applications. Although Canadian numbers are lacking, on a global basis, industrial applications may account for only three percent of land use, with animal feed around 70% (excluding grazing) (Carus & Dammer, 2013). Of course, many crops have bi- or tri-modal uses. Oilseed crops produce oil for human and industrial uses and oilseed crush goes to animal feed. Therefore, reductions in one use will have impacts on the others as well. The so-called “opportunity biomass” can still fit within this new framework, whereas “purpose-grown” biomass requires more precise analysis. Also important is that certain biomass has competing uses. Barley straw, for example, is generally the most desired for cattle bedding and roughage. When it is unavailable, oat straw and wheat straw are next best. Flax straw and corn stover are less likely to be used[52]. Excessive removal of surface residues for feed, bedding or industrial applications can lead to soil erosion.

---

[51] The data released from the 2011 Census of Agriculture is too inexact to undertake land use estimates and the biomass index mapping and analysis identifies what might theoretically be available for opportunity biomass but not purposely-planted agricultural biomass.

[52] AAFC’s biomass inventory mapping and analysis is in part helpful for these issues. http://www.agr.gc.ca/atlas/bimat

Table 3: Feedgrain shifts under a DSC regime (estimates triangulated from a range of industry sources and news reports)

Feed	Est. human / animal / indust – pharma allocation	More desirable scenario	Implications
Wheat	85/10/5	No domestic feed wheat production, only human varietes that do not meet human market requirements sold as animal feed. No industrial applications except straw for construction.	Feed wheat varieties only developed and planted for export markets
Barley	78/20/trace	More barley used for direct human consumption; significant declines in acreage for animal feed.	Need to change diet to increase barley intake (most currently used in alcohol production).
Oats (grain)	55/35/10	Animal feed for the horse (performance) and farm production (feed) sectors. Feed includes grain, straw and fodder. Oats likely a more suitable feed choice than many others from environmental perspective	Increasing human oat consumption is desirable from health perspective.
Corn	20/60/20	Major reductions in corn acreage, across both animal, human and industrial applications	Very few current corn applications meet ecological and health requirements. Shift to silage from grain corn.
Soybean	75 (oil from crush and beans)/feed-grade 15 (plus crush by-product) /10 (plastic, industrial oil, biodiesel)	Only use non-human grade beans for industrial applications, Crush residue is suitable for animal feed	Animal population reductions would result in significant acreage declines. Soybean oil not that good for human consumption.
Canola	40/50/10	90% is exported, so dramatic reductions in canola acreage to meet domestic crop rotation requirements is desirable	Farmers shift out of canola to other crops
Hay / fodder / pasture	0/99/emerging for fuel and biomaterials	Only spoiled hay for non-animal uses	The shift out of feed grains means ruminant feeding primarily on hay/fodder/pasture

Many animal products also have this multimodal use pattern since not all of a carcass is edible. For example, a beef animal is only about 55% human edible material, with the rest going to other purposes, including leather products. Edible rendered products include tallow and solids, inedible ones go into pet foods, meat and bone meal, biodiesel, soaps, grease and other lubricants, candles, rubbers, and plastics. This reuse of animal material dramatically reduces waste. Canada has lost some of its capacity to process secondary products (e.g., most tanning operations are now offshore), so this needs to be re-established.

The existing studies on optimal consumption suggest the following outcomes from DSC: reductions in production of field corn, soybeans, spring wheat, barley, canola, sunflower, dairy, beef, pork and chicken; and significant increases in pasture, hay and alfalfa, pulses, vegetables (except perhaps sweet corn, tomatoes), small fruits, grapes, pome fruits and stone fruits (Van Bers & Robinson, 1993; Desjardins et al, 2010). Some production would experience market and use re-allocations, such as greenhouse vegetables shifting from export to domestic markets, flax from industrial to human consumption, or oats from animal feed to human markets.

DSC likely has to be carried out under a combination of federal and provincial authority (enabling federal legislation exists for supply management), especially to address cross border movement of goods to equalize supply amongst provinces. Under the constitution, the provinces are responsible for private property and land use, and also for hospitals. Recent convention has health care as a joint federal-provincial responsibility.

However, the BNA Act (section 95) gives concurrent power to provinces and the federal government over agriculture. In case of a conflict, the federal government is paramount although production control for conservation is likely under provincial authority. Setting prices would appear to be under federal trade and commerce authority if natural resource goods (food might be so viewed) are traded beyond provincial borders. From earlier National Farm Products Marketing cases, the view emerged that the federal government can intervene in apparently provincial affairs, even if primarily provincially traded, when there is a national interest in regulating external trade (Bray, 1980), which there would be if trying to create a national demand–supply coordination system. At this stage, there is no obvious way to determine how the courts might decide such matters. Production waste might actually be considered provincial, but economic waste would be federal. Since the model proposed here uses the economic value of waste to drive compliance, federal authority might rule the day.

What follows then are proposals to change existing provincial (Table A3 in the Appendix) and federal legislation. These amendments could come forward as modifications to the existing legislation, or could be an Act that amends other acts.

At a federal level, the Farm Products Agencies Act[53] would permit a new category of agency, the National Food Demand-Supply Coordination Council, that establishes optimal demand and does supply calculations. This agency could be designed based on the lessons of similar structures and processes created during WWII to coordinate demand and supply (Britnell

[53] Available at: http://laws-lois.justice.gc.ca/eng/acts/F-4/page-1.html

& Fowke, 1962; Mosby, 2014). This would not require producer majority agreement as is the case for supply managed commodities, so those provisions in existing legislation have to be changed.

Sewage sludge and humanure application to land to close nutrient and energy loops

- **Sewage water, nutrient and energy recovery and distribution**
  Problems addressed: nutrient inefficiencies and recovery

At the redesign stage, sewage treatment facilities shift from being waste disposal locations, to water, nutrient and energy recovery and distribution centres. While there are now many tremendous examples of improved overall effectiveness regarding treatment and reduction of discharges,

> the public health and environment-based model of the 'traditional' wastewater treatment utility that evolved over the last 150 years has had as its principal objectives, to collect and transport human and industrial waste-water quickly and as far downstream as possible to central treatment works that could purify it sufficiently and cost-effectively so that when discharged, receiving waters would meet applicable environmental standard (National Association of Clean Water Agencies (NACWA), the Water Environment Research Foundation (WERF) and the Water Environment Federation (WEF), 2013, p. 5)

Within an agroecological framework, the focus shifts to closing the nutrient loops while sustaining or improving sanitation and public health objectives. For example, some analysts believe 100% recycling of P from waste systems will be required to avert a P availability crisis in the long term (Ashley et al., 2011). This objective would need to be implemented in association with many other measures proposed here that have significant P use efficiency and recovery dimensions (Cordell et al., 2011).

According to one report, examples of cross-cutting, functional goals for nutrient management include:

- maximizing the capture and reuse of waste stream nutrients;
- minimizing the energy used to process wastewater;
- minimizing nutrient release into the environment;
- minimizing alternations to the hydrological cycle;
- minimizing the release of GHG emissions from infrastructure; and
- maximizing economic benefits. (The Johnson Foundation, 2014, p. 5)

On a decentralized scale, households would need to be designed with urine separation and dry household solid waste systems, obviously with huge implications for household design, building codes and neighbourhood waste management systems. A key additional challenge is moving nutrients to farms. Given existing built infrastructure, such redesigns may only be feasible in the construction of new neighbourhoods and communities that are integrated with food production[54].

Financing the changes

Financing the transition can be considered at two levels: of the firm/institution and across supply chains. Although the firm/institution is typically taken as the unit of analysis, looking across supply chains is important. The costs of reducing food waste may be borne at one stage of the supply chain, while the benefits may accrue in another stage. Alternately, the costs may occur upfront, with the benefits, if any, resulting later. Finally, the reductions (and costs and benefits) may only result from collaboration among different supply chain actors. For example, farmers may seek to reduce waste by improving their storage facilities; however, if they do not have adequate market access or receive a suitable price for their additional crop, it may not be worth the investment (Rutten, 2013).

Firms and institutions

The policy and programme changes proposed here will, in many cases, impose new upfront costs on firms and institutions. Case studies suggest, however, that food waste reductions can, in many instances, produce substantial operational savings, or generate new revenue streams[55], especially if the waste reductions are captured early in supply chains (Gooch & Felfel, 2014). Gooch and Felfel (2014, p. 5) remarked "How many items must a retailer, manufacturer, distributor, or farmer sell to cover the costs borne from each item wasted or lost? To our surprise, this is a question that businesses typically cannot answer." WRAP U.K. (2014) estimated that the average firm could reduce operating costs by 15 to 20% and increase profitability by five to eleven percent. A full regulatory impact analysis is beyond the scope of this paper, but we provide here some scenarios that suggest what might be feasible.

Uzea et al. (2014) summarized the experience of a Tim Hortons' supplier that saved almost half a million dollars a year from a waste discharge reduction project, with corresponding significant savings in electricity, natural gas and water. The increased revenue for the plant also generated a substantial net increase in revenue for the government, in that the added taxes

[54] The possibilities have been explored in Magid, Eilersen, Wrisberg, & Henze (2006).
[55] Unfortunately, most studies have not taken account of O'Brien's (2013) warning regarding surplus accumulation so some of the revenue projections will be overestimates within our framework of analysis.

amounted to over $140,000. Government support to help identify the appropriate program for the firm to employ only amounted to $4000.

Augustana College[56], a small college of 2500 students in western Illinois, U.S., has figured out how to source a significant percentage of its food locally, send the food scraps back to those farms, and save money at the same time. Being in a semi-rural area has probably made it easier to set up these short supply-and-reuse chains.

Hospitals are receiving considerable attention because of the poor food quality and high waste levels. Hospital beds in Ontario cost about $1200 per day, but hospital food is only $6 to 12 per day. With labour and other costs, it comes to $30 to 35 per day (Wylie-Toal, 2013; Mintz, 2016). In many cases, 40% of the food served is returned to the kitchen. The premise is that greater patient satisfaction with food reduces waste. Hospitals could save money by eliminating items that are infrequently eaten or portions that are too big, providing patient menu selection, buying only from suppliers who will take back the packaging, using better food forecasting and performing regular tray audits. Following these reduction efforts, there might also be savings on the disposal side as two-thirds of hospitals put food waste in the regular waste stream and do not segregate for composting or other possibilities (Mior, 2009).

It has been suggested that waste savings can finance the improvements in hospital food service. Let us suppose that waste is cut in half, to 20%, resulting in an additional $1.50 in food available for consumption. Though difficult to quantify, that $1.50 could have multiple positive impacts. According to one case example from a Toronto hospital, improving the food ingredients and quality of the food would increase costs within that $1.50 projected savings (Mintz, 2016). It could improve health status of patients who are eating more and better and potentially reduce time in hospital. It might mean a reduction in food procurement costs, if patients do not eat more, and the portion sizes are made more appropriate. The same amount of food would be spread over more patients, also making labour expenses more efficient. Regarding waste disposal savings, approximately 17.3% of the hospital waste stream is organic waste, and non-hazardous waste disposal costs range from $71 to 116 per tonne (Ontario Hospital Association, n.d.). Ontario hospitals discarded an average of 0.22 to 0.67 kg of food and packaging waste per meal served (Strashok, Dale, Herbert, & Foon, 2010). Reducing this waste by half, however, only saves about $0.07 per day[57], because disposal costs are currently so low. With higher fees and ultimately a landfill ban, it becomes more feasible for waste disposal costs to finance food service improvements.

[56] Details available at: http://www.augustana.edu/x9085.xml

[57] By some estimates, food packaging waste is about one-quarter by weight of food waste weight. So, let us presume that disposal costs $100 per tonne and $17 of that is food waste. The average hospital site in Ontario has 140 beds (31000 beds divided by 224 sites). We assume 0.45 kg per meal served is waste and 80% of that is food waste, so 0.36 kg per meal. Reducing food waste by one-half means reducing the weight to 0.18 kg per meal. We also assume 95% bed occupancy on any given day. Three meals per day x 140 beds x .95 x 0.18 kg = 71.2 kg per day in saved food waste.

For food retailers, revenue from diversion of food waste to marketable products such as compost and biogas is another way of financing early stage transitions. See our estimates in Table 4 from research conducted on a major Canadian retailer.

Table 4: Potential costs of different waste management methods for a major Canadian retailer (authors' calculations from document analysis and interviews)

Potential Disposal Method Costs

Method of disposal	Cost $ (based on LCL figures for 1 period)	Potential Revenue Stream
Landfill	$2,460	✖
Anaerobic Digestion facility	$2,385	✔
Composting facility (large scale)	$2,385	✔
On-site composting	$897	✔
Farm feed application/ Animal feed	$1,323	✔
Reclamation/Donations	$0	✖
Incineration	n/a	✖

However, later stage reductions in food waste will shrink these revenues, so great care must be taken to properly scale revenue generation initiatives and avoid the surplus accumulation inclinations of firms as described by O'Brien (2013).

Across supply chains

WRAP U.K. claims their initiatives have resulted in a reduction of 670,000 tonnes of food waste throughout the U.K., saving £700 million for consumers and £20 million for governments in 2012. They estimate that every pound (£) invested in Love Food, Hate Waste saves £500 (WRAP U.K., n.d.). "Many big brands have embraced this agenda, recognizing the commercial benefit. Less waste means less cost" (Gooch et al., 2010, p. 8). In another government-supported initiative in Europe, between the Institute of Grocery Distribution (IGD) and Cranfield University, farmers and small businesses are encouraged to "Sell More, Waste Less" by going through and evaluating the entire value chain's processes and performance in order to identify causes of food waste. The programme estimated that businesses are able to reduce their costs by

20% and increase their sales by 10% by adopting new ways of managing their value chains (Gooch et al., 2010).

Tupper and Whitebread (2011) conducted eight case studies on supply chain coordination and found a seven to one benefit to cost ratio, where the costs were largely the time spent on the project by the facilitator and the companies, and the benefits were company savings and avoided landfill taxes. Key coordination strategies included: regular meetings between suppliers and retailers; better forecasting; more precise ordering and more detailed order information and better ordering tools; changes to package design, size and colouring to facilitate communication between supplier, retailer and consumer; and pricing changes to move lower demand product.

It would appear, then, that many of the costs imposed by regulatory changes are recoverable, especially as waste disposal fees increase. How to finance demand-supply coordination requires thorough study, but given the way current Canadian marketing boards use levies on distribution or price setting powers, it would appear that many of these costs could be imposed on the market place as they are currently.

Conclusion

Food system waste is a significant indicator of system inefficiencies and its fundamentally unsustainable character, and much of it is readily avoidable. The ongoing pressure to increase production and yield performance makes little sense when so much of that production is wasted. Although some improvements are underway, they are primarily private-sector driven and voluntary, with features that are potentially counter-productive in the longer term, in part because current waste reduction frameworks are either not followed, are inadequate, or both. The most significant underlying causes of waste, and their structural linkages across supply chains are not a substantial part of the current discussion.

In particular, private and voluntary initiatives largely fail to address both overproduction of certain foods and overconsumption by significant segments of the population. It would appear that only state interventions can address such problems since reducing them runs counter to the rules of a capitalist food system. To date, Canadian governments have been minimally involved in waste reduction efforts, with no coherent and comprehensive strategy in place to improve food system performance.

Many of the initiatives proposed here build on existing legislation, regulations, structures and processes, identifying minor amendments that add food waste reduction to efforts in other sectors. We modified existing food waste reduction hierarchies to both extend our understanding of food systems and create better linkages across the food chain as it relates to waste generation. We employed a transition framework to bring temporal and resourcing order to proposals and offered some preliminary suggestions on financing implications. In our process of change, governments intervene to set new conditions that private and public actors must respond to, a regulatory pluralism approach that does not impose the burdens of change on one sector. What we propose requires a collaborative effort across private and public actors, NGOs and eaters themselves. A summary of our proposed initiatives and their relationship to our food waste management hierarchy is provided in Table 5.

Table 5: Summary of strategies

Hierarchy Elements / **Transition strategies**	***Level 1: Human edibles (resource efficient)***	***Level 2: Animal edibles***	***Level 3: Human and animal inedibles for industrial use***	***Level 4: Sewage and humanure***
General	Better data Targets	Better data Targets	Better data Targets	Better data Targets
Efficiency	Education campaigns	Expanding suitable feeds	Backyard, community, curbside compost	Sewer separation
	Food label changes		Increase tipping fees	
	Improving food donation		Improving Waste-free legislation	
	Technology changes		Improving deadstock handling	
	Packaging changes		Transition for rendering	
	Size and portion changes			
Substitution	Environmental protocols	Environmental protocols	Curbside collection MURBs and commercial	Land application
	Grading changes	Plate waste regulatory change	Landfill ban	New settlement systems
	Regulating processing varieties			Composting toilets
	Requiring sustainable procurement			
	Advertising			
	Design standards			
Redesign	Demand-supply coordination	Demand-supply coordination	Demand-supply coordination	Water, nutrient and energy recovery and distribution

The redesign stage is the least developed area at this point. In future work, we plan to delve deeply into demand–supply coordination in the Canadian food system. This work will involve a detailed review of government instruments and structures employed during WWII, the only moment in which Canada actually had a sophisticated DSC system in place, with lessons for constructing a new apparatus to bring it into place again. The ultimate purpose is to make sure we optimize the value of what we already have.

References

Abdulla, M., Martin, R.C., Gooch, M., & Jovel, E. (2013). The importance of quantifying food waste in Canada. *Journal of Agriculture, Food Systems, and Community Development, 3*(2), 137–151.

Agriculture and Agri-food Canada (AAFC). (2012). *An overview of the Canadian agriculture and agri-food system.* Ottawa: AAFC.

Alexander, C., Gregson, N., & Gille, Z. (2013). Food waste. In A. Murcott, W. Belasco, & P. Jackson (Eds.). *The handbook of food research* (pp. 471-484). London: Bloomsbury.

Alfred, E. (2013). *Toronto resident's guide to waste*. Toronto: Toronto Environmental Alliance. Retrieved from http://www.torontoenvironment.org/sites/tea/files/TEA%20-%20Toronto%20Residents%27%20Guide%20to%20Waste%20-%202013%20-%20web.pdf

Anderson, S. (2014, October 10). High tipping fees driving business to United States: Regional district boasts high diversion rate. *Nanaimo Daily News.* Retrieved from http://www.nanaimodailynews.com/news/300471211.html?mobile=true

Ashley, K., Cordell, D., & Mavinic D. (2011). A brief history of phosphorus: From the philosopher's stone to nutrient recovery and reuse. *Chemosphere, 84*(6), 737-746**.**

Bloom, J. (2010). *American wasteland: How America throws away nearly half of its food and what we can do about it.* Cambridge, MA: Da Capo Press.

Bray, C.E. (1980). Agricultural land regulation in several Canadian provinces. *Canadian Public Policy, 6*(4), 591-604.

Britnell, G.E., & Fowke, V.C. (1962). *Canadian agriculture in war and peace: 1935-1950*. Stanford, CA: Stanford University Press.

Buckingham, D. (2014). *Halsbury's laws of Canada – Food*. Markham, ON: LexisNexis,.

Burch D., & Lawrence, G. (2009).Towards a third food regime: Behind the transformation. *Agriculture and Human Values, 26*, 267-279.

Business for Social Responsibility (BSR). (2013). *Analysis of U.S. food waste among food manufacturers, retailers, and wholesalers.* Washington, DC: Food Waste Reduction Alliance.

Business Green. (2012, January 9). Could long-lasting M&S strawberries reduce food waste? Retrieved from http://www.businessgreen.com/bg/news/2135806/-lasting-strawberries--reduce-food-waste.

Buzby, J.C., & Hyman, J. (2012). Total and per capita value of food loss in the United States. *Food Policy, 37*, 561-570.

Campbell, H. (2002). The rise and rise of Eurep-GAP: European re(invention) of colonial food relations? *International J. Sociology of Food and Agriculture, 13*(2), 1-19.

Campbell, H. (2009). Breaking new ground in food regime theory: Corporate environmentalism, ecological feedbacks and the food from somewhere regime? *Agriculture and Human Values, 26*, 309-319.

Canadian Food Inspection Agency (CFIA). (2014). *Food labelling and advertising.* Retrieved from http://www.inspection.gc.ca/food/labelling/eng/1299879892810/1299879939872

Canadian Food Inspection Agency (CFIA). (2014a). *Chapter 3 - specific registration information by feed type*. Retrieved from http://www.inspection.gc.ca/animals/feeds/regulatory-guidance/rg-1/chapter-3/eng/1329319549692/1329439126197?chap=19

Carus, M., & Dammer, L. (2013) Food or non-food: Which agricultural feedstocks are best for industrial uses? *Industrial Biotechnology, 9*(4).

Cech, P. (2016, Feb. 17-18). Presentation to *Building a research agenda for food waste in Ontario*. Guelph, ON Retrieved from https://www.youtube.com/watch?v=Z8WGl29p2YY

Center for Disease Control (CDC). (n.d.) *Making health easier*. Atlanta: CDC. Retrieved from http://www.cdc.gov/makinghealtheasier/

Chou, S-Y., Rashad, I., & Grossman, M. (2008). Fast-food restaurant advertising on television and its influence on childhood obesity. *Journal of Law and Economics, 51*(4), 599-618.

Chrisafis, A. (2016, Feb. 4). French law forbids food waste by supermarkets. *Guardian*. Retrieved from https://www.theguardian.com/world/2016/feb/04/french-law-forbids-food-waste-by-supermarkets

Clark, B., & York, R. (2008). Rifts and shifts: Getting to the root of environmental crisis. *Monthly Review, 60*(6). Retrieved from http://monthlyreview.org/2008/11/01/rifts-and-shifts-getting-to-the-root-of-environmental-crises/

Cliff, M. (2014, July 16). Forgot the ugli fruit, meet the ugly fruit bowl! *Daily Mail Online*. Retrieved from http://www.dailymail.co.uk/femail/food/article-2693000/Forget-ugli-fruit-meet-ugly-fruit-bowl-French-supermarket-introduces-lumpy-misshapen-fruit-vegetables-sold-30-discount-combat-food-waste.html

Cooke, D., Stanley, C. Carter, H., & Whitehead, P. (2014). *Resource efficient and sustainable buying in grocery supply chains* (PAD102-309). London: WRAP U.K. Retrieved from http://www.wrap.org.uk/sites/files/wrap/Research%20report_Resource%20efficient%20and%20sustainable%20buying%20in%20grocery%20supply%20chains.pdf

Cordell, D., Rosemarin, A., Schröder, J.J., & Smit, A.L. (2011). Towards global phosphorus security: A systems framework for phosphorus recovery and reuse options. *Chemosphere, 84*(6), 747-758.

Crew, T.E., & Peoples, M.B. (2004). Legume versus fertilizer sources of nitrogen: Ecological tradeoffs and human needs. *Agriculture, Ecosystems and Environment, 102,* 279-297.

Crosby, D. (2009, April 20). Deadstock change deadly to little guy. *Today's Farmer*. Retrieved from http://www.todaysfarmer.ca/2009/04/20/deadstock-change-deadly-to-little-guys

Cuéllar, A. & Webber, M. (2010).Wasted food, wasted energy: The embedded energy in food waste in the United States. *Environmental Science and Technology, 44,* 6464–6469.

Dempsey, G. (2013). *Farmland preservation and Protected Area Management: Lessons from the Cuyahoga Valley National Park* (Unpublished master's thesis). Faculty of Environmental Studies, York University, Toronto, ON.

Desjardins, E., MacRae, R., & Schumilas, T. (2010). Meeting future population food needs with local production in Waterloo Region: Linking food availability and optimal nutrition requirements. *Agriculture and Human Values, 27*(2),129-140.

Dhar, T., & Baylis, K. (2011). Fast-food consumption and the ban on advertising targeting children: The Québec experience. *Journal of Marketing Research, 68*, 799-813.

Economic Research Service (ERS). (2011). *Loss-adjusted food availability data*. Washington, DC: U.S. Department of Agriculture.
Erisman, J.W., Sutton, M.A., Galloway, J., Klimont, Z., & Winiwarter, W. (2008). How a century of ammonia synthesis changed the world. *Nature GeoScience, 1*(28 Sept), 636–639.
European Commission (EC). (2012). *Directive 2008/98/EC on waste*. Brussels: Waste Framework Directive, EC. Retrieved from http://ec.europa.eu/environment/waste/framework/.
Escobar, T. (2010, Feb. 5). McDonald's looks for new spuds. *Columbia Basin Herald*. Retrieved from http://www.columbiabasinherald.com/news/local_business/article_f39d4673-f21f-569e-96de-04adf82615ea.html
Evans, D. (2011). Blaming the consumer - once again: The social and material contexts of everyday food waste practices in some English households. *Critical Public Health, 21*(4), 429-440.
Evans, D. (2012). Beyond the throwaway society to ordinary domestic practice: What can sociology say about food waste? *Sociology, 46*(1), 41-56.
Evans, D., Campbell, H., & Murcott, A. (2013). A brief pre-history of food waste and the social sciences. *The Sociological Review, 60*(S2), 5-26.
Food and Agriculture Organization (FAO). (2013). *Food wastage footprint: Impacts on natural resources*. Rome: FAO. Retrieved from http://www.fao.org/docrep/018/i3347e/i3347e.pdf
Forkes J. (2011). *Measuring the shape and size of the foodshed* (unpublished PhD thesis), Dept. Geography, University of Toronto, Toronto, ON.
Fortin, P-O. (2014, June 28). Des legumes moches, bons, pas chers. *Le Soleil*. Retrieved from http://www.lapresse.ca/le-soleil/affaires/agro-alimentaire/201406/27/01-4779518-des-legumes-moches-bons-pas-chers.php
Foster, B. (1999). Marx's theory of metabolic rift: Classical foundations for environmental sociology. *American Journal of Sociology, 105*(2), 366-405.
Foster B., & Magdoff, F. (1998). Liebig, Marx, and the depletion of soil fertility: Relevance for today's agriculture. *Monthly Review, 50*(3), 32.
Friedmann, H. (2000). What on earth is the modern world-system? Foodgetting and territory in the modern era and beyond. *Journal of World-Systems Research, 6*, 480-515.
Friedmann, H. (2005). From colonialism to green capitalism: Social movements and the emergence of food regimes. In F. Buttel & P. McMichael (Eds.). *New directions in the sociology of global development* (pp. 227-264). Research in rural sociology and development, Volumen 11. Amsterdam: Elsevier.
Friedmann, H. (2009). Discussion: Moving food regimes forward: reflections on symposium essays. *Agriculture and Human Values, 26*, 335-344.
Friedmann, H., & McMichael, P. (1989). Agriculture and the state system: The rise and decline of national agriculture. *Sociologia Ruralis, 19*(2), 93-117.
Friesen, B. (2000, January 1). Landfill ban stimulates composting programs in Nova Scotia. *Biocycle*. Retrieved from http://www.environmental-expert.com/articles/landfill-ban-stimulates-composting-programs-in-nova-scotia-1117

Galliot, L. (2014, July 29). The latest French fashion: Eating ugly fruits and vegetables. *Grist* Retrieved from http://grist.org/food/the-latest-french-fashion-eating-ugly-fruits-and-veggies/?utm_source=New+HEN+distribution+list&utm_campaign=d2e388cd4a-HEN_E_Bulletin_140820&utm_medium=email&utm_term=0_2682faca70-d2e388cd4a-100598217

Garnett, T. (2006). *Fruit and vegetables and U.K. Greenhouse Gas Emissions: Exploring the relationship.* Sussex, U.K.: Centre for Environmental Strategy, University of Sussex.

Ghaffari, A., Bunch, M., MacRae, R., & Zhao, J. (2015). Socio-economic support optimization for transition from conventional to organic farming using a spatiotemporal Agent-based Model. *International Journal of Interdisciplinary Environmental Studies, 8*(3-4), 13-25.

Gidwani, V., & Reddy, R.N. (2011). The afterlives of "waste": Notes from India for a minor history of capitalist surplus. *Antipode, 43*(5), 1625-1658.

Gille, Z. (2013). From risk to waste: Global food waste regimes. *The Sociological Review, 60*(S2), 27-46.

Goldstein, N. (2013). Community composting in New York City. *Biocycle, 54*(11). Retrieved from http://www.biocycle.net/2013/11/18/community-composting-in-new-york-city/

Gooch, M., Felfel, A.,& Marenick, N. (2010). *Food waste in Canada: Opportunities to increase the competitiveness of Canada's agri-food sector, while simultaneously improving the environment.* Guelph, ON: Value Chain Management Centre.

Gooch, M. & Felfel, A. (2014). *The cost of Canada's annual food waste*. Guelph, ON: Value Chain Management International. Retrieved from http://vcm-international.com/wp-content/uploads/2014/12/Food-Waste-in-Canada-27-Billion-Revisited-Dec-10-2014.pdf

Goodwin, E. (2014). *Extending our global impact on waste*. London: WRAP U.K.

Griffin, M., Sobal, J., & Lyson, T. (2009). An analysis of a community food waste stream. *Agriculture and Human Values, 26*(1), 67-81.

Guelph Food Waste Project (GFWP). (2014). *Guelph Food Waste Project research update*. Retrieved from https://guelphfoodwaste.com/

Gunders, D. (2012). *Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill* (Natural Resources Defense Council Issue Paper). Washington: NRDC.

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., & Meybeck, A. (2011). *Global food losses and food waste*. Rome: Food and Agriculture Organization (FAO). Retrieved from http://www.fao.org/docrep/014/mb060e/mb060e00.pdf.

Harris, J. Bargh, J., & Brownell, K. (2009). Priming effects of television food advertising on eating behavior. *Health Psychology, 28*(4), 404-413.

Harrison, G., Rathje, W, & Huges, W. (1975). Waste behavior in an urban population. *Journal of Nutrition Education, 7*(1), 3-16.

Hedley, D.D. (2006). Why is there no Canadian food policy in place? *Canadian Issues, Winter*:20–27.

Hill, S.B. (1985). Redesigning the food system for sustainability. *Alternatives*, *12*(3/4),32-36.

Hill, S.B., & MacRae, R.J. (1995). Conceptual framework for the transition from conventional to sustainable agriculture. *Journal of Sustainable Agriculture, 7*, 81-87.

Hodges, R.J., Buzby, J.C., & Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use. *Journal of Agricultural Science, 149*, 37-45.

Holt-Gimenez, E., & Shattuck, A. (2011). Food crisis, food regimes and food movements: Rumbling of reform or tides of transformation? *Journal of Peasant Studies, 38*(1), 109-114.

Honeyman, M.S. (2005). Extensive bedded indoor and outdoor pig production systems in USA: Current trends and effects on animal care and product quality. *Livestock Production Science, 94*, 15-24.

Honeyman, M.S., & Lammers, P. (2011). *Energy use and nutrient cycling in pig production systems*. Ames, IA: Leopold Center for Sustainable Agriculture. Retrieved from http://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1386&context=leopold_grantreports

Jaffe, J., & Gertler, M. (2006). Victual vicissitudes: Consumer deskilling and the (gendered) transformation of food systems. *Agriculture and Human Values*, *23*(2), 143-162.

Jackson, P., Ward, N., & Russell, P. (2006). Mobilising the commodity chain concept in the politics of food and farming. *Journal of Rural Studies, 22*, 129-141.

Karolefski, J. (2015, Nov. 15). The future of demand forecasting: Usage by grocers is lagging. *Progressive Grocer*. Retrieved from http://www.progressivegrocer.com/departments/technology/future-demand-forcasting.

Kneen, B. (1992). Feeding the family, trading the leftovers. *The Ram's Horn, 91*, 1-4.

Koch, H. (2009, August). Canada's enhanced feed ban – 2 years later. *Render Magazine*. Retrieved from http://www.rendermagazine.com/articles/2009-issues/2009-august/2009-08-international-report/

Kohn, M. (2011). *The generation of food waste from supermarkets in Ontario & impacts on the food system* (Unpublished master's thesis). Faculty of Environmental Studies, York University, Toronto, ON.

Lipinski, B. Hanson, C., Waite, J. Lomax, L., Kitinoja, R., & Searchinger, T. (2013). *Reducing food loss and waste* (Working paper, installment 2 of Creating a sustainable future). Washington, DC: World Resources Institute and the UN Environment Program,. Retrieved from http://www.worldresourcesreport.org

Liu, K. (2016, March, 23). Loblaws gets ugly with its produce department. *The Star*. Retrieved from https://www.thestar.com/life/food_wine/2016/03/23/loblaws-gets-ugly-with-its-produce-department.html

Lucas, A.R., & Cotton, R. (2013). *Halsbury's laws of Canada – Environment* (2013 Reissue). , Markham, ON: LexisNexis.

Lunn, S. & Harris, K. (2016, Oct. 24). Health Minister Jane Philpott announces new food labelling, marketing rules. *CBC News*. Retrieved from http://www.cbc.ca/news/politics/food-regulation-marketing-children-jane-philpott-1.3818267

MacRae, R.J. (2014). Do trade agreements substantially limit development of local / sustainable food systems in Canada? *Canadian Food Studies*, *1*(1), 103-125**.**

MacRae, R., & Winfield, M. (2016). A little regulatory pluralism with your counter-hegemonic advocacy? Blending analytical frames to construct joined-up food policy in Canada. *Canadian Food Studies, 3*(2), 140-194.

MacRae, R.J., Hill, S.B., Henning J., & Bentley, A.J. (1990). Policies, programs and regulations to support the transition to sustainable agriculture in Canada. *American Journal of Alternative Agriculture*, *5*(2), 76-92.

MacRae, R.J., Hill, S.B., Mehuys, G.R., & Henning, J. (1990a). Farm-scale agronomic and economic conversion to sustainable agriculture. *Advances in Agronomy, 43*, 155-198.

MacRae, R.J., Henning, J., & Hill, S.B. (1993). Strategies to overcome barriers to the development of sustainable agriculture in Canada: The role of agribusiness. *Journal of Agricultural and Environmental Ethics, 6*, 21-53.

MacRae, R.J., Martin, R.C. Langer, J., & Juhasz, M. (2009). Ten percent organic within 15 years: Policy and programme initiatives to advance organic food and farming in Ontario, Canada. *Renewable Agriculture and Food Systems, 24*(2), 120-136.

MacRae, R.J., Lynch, D., & Martin, R.C. (2010). Improving energy efficiency and GHG mitigation potentials in Canadian organic farming systems. *Journal of Sustainable Agriculture, 34*(5), 549-580.

MacRae, R.J., Nasr, J., Kuhns, J., Baker, L., Christianson, R., Danyluk, M., …. Wekerle, G. (2012). Could Toronto provide 10% of its fresh vegetable requirements from within its own boundary? Part II: Policy supports and programme design. *Journal of Agriculture, Food Systems and Community Development, 2*(2), 147-169.

MacRae, R.J., Szabo, M., Anderson, K., Louden F.N., & Trillo, S. (2012a). Empowering the citizen-consumer: Re-regulating consumer information to support the transition to sustainable and health promoting food systems in Canada. *Sustainability, 4*(9), 2146-2175.

Magid, J. Eilersen, A.M., Wrisberg, S. & Henze, M. (2006). Possibilities and barriers for recirculation of nutrients and organic matter from urban to rural areas: A technical theoretical framework applied to the medium-sized town Hillerød, Denmark. *Ecological Engineering, 28*, 44–54. Retrieved from http://cemusstudent.se/wp-content/uploads/2012/05/Magid-Urban-Rural-Nutrients-2006.pdf

Maguire, M. (2016). *Wasted potential: A food waste reduction strategy for Toronto restaurants* (Unpublished master's thesis). Faculty of Environmental Studies, York University, Toronto, ON.

Marr, A. (2016, Feb. 17-18). Presentation to *Building a research agenda for food waste in Ontari*o. Guelph, ON. Retrieved from https://www.youtube.com/watch?v=gQSwyo4hMvs

Maxime, D., Arcand, Y., Landry, D., & Marotte, M. (2010). Water use. In W. Eilers, R. MacKay, L. Graham, & A. Lefebvre (Eds.). *Environmental sSustainability of Canadian agriculture* (Agri-environmental indicator report series — Report #3). Ottawa: Agriculture and Agri-Food Canada.

McCallum, D., Campbell, A.M., & MacRae, R. (2014). Can large retailers localize supply chains? A case analysis of the challenges facing one Canadian retailer. *Journal of Agriculture, Food Systems, and Community Development, 4*(2), 163-176.

McMichael, P. (2005). Global development and the Corporate Food Regime. In F.H. Buttel & P. McMichael (Eds.). *New directions in the sociology of international development* (pp. 269-303). Research in Rural Sociology and Development, Vol. 11. Amsterdam: Elsevier.

McMichael, P. (2009). A food regime genealogy. *Journal of Peasant Studies*, *36*(1), 139–169.

Mena, C., Adenso-Diaz, B., & Yurt, O. (2011). The causes of food waste in the supplier–retailer interface: Evidences from the UK and Spain. *Resources, Conservation & Recycling, 55*(6), 648-658.

Metro Vancouver (n.d.). *Love food hate waste*, Retrieved from http://www.lovefoodhatewaste.ca/about/Pages/default.aspx

Midgley, J.L. (2013). The logics of surplus food redistribution. *Journal of Environmental Planning and Management, 57*(12), 1872-1892.

Miller, G. 2012. *Losing our touch: Annual report 2011/2012, part 2*. Toronto, ON: Environmental Commissioner of Ontario (ECO). Retrieved from http://docs.assets.eco.on.ca/reports/environmental-protection/2011-2012/2011-12-AR.2.pdf

Ministry of Environment and Climate Change (MOECC). (2015). *Draft strategy for a waste free Ontario: Building the circular economy*. Toronto, ON: MOECC. Retrieved from http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2015/012-5834_DraftStrategy.pdf

Mintz, C. (2016, May 11). Not up to scratch. *Globe and Mail*, L1,3.

Mior, C.(2009). *Strategies to reduce waste in patient food services*. Toronto, ON: Aramark Healthcare. Retrieved from http://www.greenhealthcare.ca/images/publications/h2010102%20waste%20reduction%20research%20paper.pdf

Moore, J. (2000). Environmental crises and the metabolic rift in world-historical perspective. *Organization and Environment*, *13*(2), 123–157.

Moore, J. (2011). Transcending the metabolic rift: Theory of crisis in the capitalist world-ecology. *Journal of Peasant Studies, 38*(1), 1-46.

Morris, J., Matthews, S., & Morawski, C. (2011). *Review of LCAs on organics management methods & development of an environmental hierarchy*. Edmonton, AB: Alberta Environment, Retrieved from https://extranet.gov.ab.ca/env/infocentre/info/posting.asp?assetid=8350&categoryid=20

Mosby, I. 2014. *Food Will Win the War*. Vancouver: UBC Press.

National Association of Clean Water Agencies (NACWA), the Water Environment Research Foundation (WERF), & the Water Environment Federation (WEF). (2013). *Water resources utility of the future . . . blueprint for action.* Washington and Alexandria, VA: NACWA, WERF, WEF. Retrieved from http://www.nacwa.org/images/stories/public/2013-01-31waterresourcesutilityofthefuture-final.pdf

National Zero Waste Council. (2016). *Reducing food waste & cutting Canada's carbon emissions: Policies for reaping the environmental, economic and social benefits*. Ottawa: NZWC. Retrieved from http://www.nzwc.ca/Documents/NZWCSubmissionOnPan-anadianFrameworkForCombattingClimateChange.pdf

New Democratic Party (NDP). (2014, March 3). *It's time for action to reduce food waste: NDP*. Retrieved from http://www.ndp.ca/news/its-time-action-to-reduce-food-waste-ndp

New South Wales Food Authority, (2010). *Shelf-life testing: 'Use-by' dates for food safety*. Retrieved from http://ucfoodsafety.ucdavis.edu/files/49285.pdf

New Zealand Government. (2012). *How to determine the shelf-life and date marking of food: A draft guidance document (MPI Discussion Paper No: 2012/27)*. Wellington, NZ: Government of New Zealand. Retrieved from http://www.foodsafety.govt.nz/elibrary/industry/determine-shelf-life-of-food/

Nielsen, S. J., & Popkin, B.M. (2003). Patterns and trends in food portion sizes, 1977-1998. *Journal of the American Medical Association*, *289*(4), 450-453.

O'Brien, M. (2013). A 'lasting transformation' of capitalist surplus: From food stocks to feedstocks. *The Sociological Review, 60*(S2), 192-211.

Ontario Hospital Association. (n.d.) *Findings of the green hospital champion fund energy and waste audit program: Opportunities for Ontario's hospitals.* Retrieved from http://www.oha.com/CurrentIssues/keyinitiatives/eHealth/PublishingImages/GHCF%20Audit%20Findings%20Report%20FINAL.pdf

Ontario Ministry of the Environment (OMOE). (2012). *Guideline for the production of compost in Ontario, part 2*. Toronto, ON: OMOE. Retrieved from https://dr6j45jk9xcmk.cloudfront.net/documents/1230/101-production-of-compost-en.pdf

Ontario Ministry of the Environment. (2012a). *Ontario compost quality standards*. Toronto, ON: OMOE. Retrieved from https://www.ontario.ca/page/ontario-compost-quality-standards

Ontario Ministry of the Environment. (2013). *Waste reduction strategy*. Toronto, ON: OMOE.

Ontario Public Interest Research Group (OPIRG). 1990. *Supermarket Tour*. Toronto, ON: OPIRG.

Ostry, A., & Morrison, K. (2013). A method for estimating the extent of regional food self-sufficiency and dietary ill health in the Province of British Columbia, Canada. *Sustainability*, *5*(11), 4949-4960. Retrieved from http://www.mdpi.com/2071-1050/5/11/4949/htm

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: Quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365*(1554), 3065-3081.

Parizeau, K., von Massow, M., & Martin, R. (2015). Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in a municipality in Southwestern Ontario. *Waste Management*, *35*, 207-217.

Parks, S. & Gowdy, J. (2013). What have economists learned about valuing nature? A review essay. *Ecosystem Service, 3*, e1-e10.

Peel Region. (2016, Sept 14). *News Release*. Retrieved from https://www.peelregion.ca/news/archiveitem.asp?year=2016&month=8&day=14&file=2016814.xml

Perreault, D. (2015). *Selling unattractive food to decrease waste and encourage sustainable consumer behaviour in France: Lessons for Québec food retailers* (Unpublished master's thesis). Faculty of Environmental Studies, York University, Toronto, ON.

Prasada, P., Bredahl, M.E., & Wigle, R. (2010). Market impacts of technological change in Canadian agriculture. *Canadian Journal of Agricultural Economics*, *58*(2), 235-247.

Pretty, J.N., Brett, C., Gee, D., Hine, R., Mason, C.F., Morison, J.I.L., …. . van der Bijl, G. 2000. An assessment of the total external costs of UK agriculture. *Agricultural Systems, 65*, 113–136.

Price, A. (2009, June 19). 'Humanure' victory: Green toilet wins Austin City approval. *Common Dreams*. Retrieved from http://www.commondreams.org/news/2009/06/19/humanure-victory-green-toilet-wins-austin-city-approval

Proulx, D. (2014, July 29). Fruits et legumes moches: Des milliers de tonnes jetées au Québec. *Groupe TVA.* Retrieved from http://argent.canoe.ca/nouvelles/fruits-et-legumes-moches-des-milliers-de-tonnes-jetees-au-Québec-29072014

Quested, T., & Johnson, H. (2009). *Household food and drink waste in the UK.* London: WRAP U.K. Retrieved from http://www.wrap.org.uk/sites/files/wrap/Household_food_and_drink_waste_in_the_UK_-_report.pdf

Rathje, W., & Murphy, C. (1992). *Rubbish: The archaeology of garbage.* New York: Harper Collins.

Regional Municipality of York, (2013). *Review of Bill 91, proposed Waste Reduction Act, 2013.* Retrieved from http://archives.york.ca/councilcommitteearchives/pdf/sep%2019%20es%20review.pdf

Richards, C., Bjørkhaug, H., Lawrence, G. & Hickman, E. (2013). Retailer-driven agricultural restructuring: Australia, the UK and Norway in comparison. *Agriculture and Human Values, 30*(2), 235-245.

Rosenblatt, S. (2009). *The feasibility of a restaurant transition to a sustainable meat supply-chain: A case study of two Toronto restaurants* (Unpublished master's thesis). Faculty of Environmental Studies, York University, Toronto, ON.

Rutten, M. M. (2013). What economic theory tells us about the impacts of reducing food losses and/or waste: Implications for research, policy and practice. *Agriculture and Food Security, 2*, 1-13.

Samuel, H. (2016, March 15). Italy set to pass new law to fight food waste. *Telegraph*. Retrieved from http://www.telegraph.co.uk/news/worldnews/europe/italy/12194549/Italy-set-to-pass-new-law-to-fight-food-waste.html

Seccombe, W. (2013, March 19). *Mid-size compost strategy: Comment at the Public Works and Infrastructure Committee*. Retrieved from http://tfpc.to/uncategorized/mid-size-compost-strategy-by-wally-seccombe-presented-to-the-public-works-and-infrastructure-committee-march-19-2013

Schneider, F. (2008, May 11-15). Wasting food: An insistent behaviour. Presentation to *Waste – The social context 2008: Urban issues and solutions*. Edmonton, Alberta. Retrieved from http://www.ifr.ac.uk/waste/Reports/Wasting%20Food%20-%20An%20Insistent.pdf

Schneider, M., & McMichael, P. (2010). Deepening, and repairing the metabolic rift. *Journal of Peasant Studies, 37*(3), 461-484.

Siu, A. (2015). *An analysis of food waste in Ontario's domestic fresh strawberry supply chain* (Unpublished master's thesis). Faculty of Environmental Studies, York University, Toronto, ON.

Smil, V. 2001. *Feeding the world: A challenge for the 21st century*. Cambridge MA: MIT Press.

Smil, V. 2004. Improving efficiency and reducing waste in our food system. *Environmental Sciences 1*(1), 17-26.

Specht, J. (2013). Food waste fighter: An interview with Jonathan Bloom**.** *Food Tank*. Retrieved from http://foodtank.org/news/2013/06/food-waste-fighter-an-interview-with-jonathan-bloom

Statistics Canada. (2009). *Human activity and the environment: Annual statistics* (Section 1: Food in Canada). Ottawa, ON: Statistics Canada. Retrieved from http://www.statcan.gc.ca/pub/16-201-x/2009000/part-partie1-eng.htm

Strashok, C., Dale, A., Herbert, Y., & Foon, R. (2010). *Greening Canadian hospitals* (Community Research Connections Discussion Paper #7). Victoria, BC: Royal Roads University. Retrieved from https://crcresearch.org/files-crcresearch_v2/File/Discussion_Paper-7_Greening_Canadian_Hospitals.pdf

Stuart, T. (2009). *Waste: Uncovering the global food scandal.* New York: W.W. Norton.

Sun Media, (2009, April 3). Deadstock removal crisis. *The Post.* Retrieved from http://www.thepost.on.ca/2009/04/03/deadstock-removal-crisis

Tegtmeier, E.M., & Duffy, M.D. (2004). External costs of agricultural production in the United States. *International Journal of Agricultural Sustainability*, *2*, 1-20.

Terry, L.A., Mena, C., Williams, A, Jenney, N., & Whitehead, P. (2011). *Fruit and vegetable resource maps* (Project code RSC008). London: WRAP U.K. Retrieved from http://www.wrap.org.uk/sites/files/wrap/Resource_Map_Fruit_and_Veg_final_6_june_2011.fc479c40.10854.pdf

The Johnson Foundation at Wingspread. (2014). *The road toward smarter nutrient management in municipal water treatment*. Racine, WI: The Johnson Foundation at Wingspread. Retrieved from http://www.johnsonfdn.org/sites/default/files/conferences/whitepapers/14/03/10/cnw_smarter_nutrient_management_0.pdf

Tobin, T. (2016). Blog: What we can do about Canada's food waste problem. Retrieved from http://www.huffingtonpost.ca/tommy-tobin/canada-food-waste_b_11071690.html

Toronto Food Policy Council (TFPC). (1994). *Reducing urban hunger in Ontario: Policy responses to support the transition from food charity to local food security* (TFPC Discussion Paper #1). Toronto: TFPC, Retrieved from. http://www1.toronto.ca/city_of_toronto/toronto_public_health/healthy_families/nutrition/toronto_food_policy_council/files/pdf/tfpc_hunger.pdf

Toronto Food Policy Council. (1996). *Food retail access and food security for Toronto's low-income citizens* (TFPC Discussion Paper #7). Toronto, ON: TFPC. Retrieved from http://www1.toronto.ca/city_of_toronto/toronto_public_health/healthy_families/nutrition/toronto_food_policy_council/files/pdf/tfpc_food.pdf

Toronto Food Policy Council (TFPC). (1997). *If the health care system believed you are what you eat* (TFPC Discussion Paper #3). Toronto, ON: TFPC.

Tupper, J., & Whitehead, P. (2011). *Reducing food waste through retail supply chain collaboration* (Project code RSC010--001). London: WRAP U.K., Retrieved from http://www.wrap.org.uk/sites/files/wrap/WRAP_IGD_supply_chain_report.pdf

U.K. Food Standards Agency. (2011). *Guidance on the application of date labels to food.* London, U.K: DEFRA. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69316/pb132629-food-date-labelling-110915.pdf

United Nations Environment Programme (UNEP). (2013, June 05). Cutting food loss and waste will benefit people and the environment, says new study on World Environment Day.. *United Nations Environment Programme News Centre.* Retrieved from http://www.unep.org/NewsCentre/default.aspx?DocumentID=2718&ArticleID=9527&l=en

U.S. Environmental Protection Agency (EPA). (2014). *Reducing food waste for businesses*. Washington, DC: U.S.EPA. Retrieved from http://www.epa.gov/foodrecovery

Uzea, N., Gooch, M., & Sparling, D. (2014). *Developing an industry led approach to addressing food waste in Canada.* Guelph, ON: Network for Business Sustainability. Retrieved from http://nbs.net/wp-content/uploads/Addressing-Food-Waste-in-Canada.pdf

Van Bers, C., & Robinson, J. (1993). Farming in 2031: A scenario of sustainable agriculture in Canada. *Journal of Sustainable Agriculture, 4*, 41-65.

Vandusen, T. (2010, March 3). Pressure rising for deadstock disposal. *Ottawa Sun*. Retrieved from http://www.ottawasun.com/news/ottawa/2010/03/03/13101686.html

Vidoni, M. (2011). *Community composting in Toronto: Closing the food-waste loop* (unpublished MA Thesis), University of Toronto, Toronto, ON. Retrieved from http://tfpc.to/wordpress/wp-content/uploads/2013/01/Community-Composting-in-Toronto-2012-DRAFT-reduced-1.pdf

Voß, J-P., Smith, A., & Grin, J. (2009). Designing long-term policy: rethinking transition management. *Policy Science, 42*, 275–302.

Water Environment Research Foundation (WERF). (2011). *Nutrient recovery: State of the knowledge*. Alexandria, VA: WERF.

Watson, E. (2014, July 7). Why do we waste so much food, and what can we do about it? *Food Navigator USA*. Retrieved from http://www.foodnavigator-usa.com/Manufacturers/Why-do-we-waste-so-much-food-and-what-can-we-do-about-it

Watson, M., & Meah, A. (2013). Food, waste and safety: negotiating conflicting social anxieties into the practices of domestic provisioning. *The Sociological Review, 60*(S2), 102–120.

Winfield, M., & MacWhirter, B. (2013). *Competing paradigms, hard path inertia and the search for sustainability in Ontario electricity policy* (Sustainable Energy Initiative Working Paper). Toronto, ON: Faculty of Environmental Studies, York University. Retrieved from http://sei.info.yorku.ca/files/2013/03/CompetingParadigms-03-12-2013.pdf

WRAP U.K. (n.d.). *Love food hate waste organic case studies*, Retrieved from http://www2.gov.bc.ca/assets/gov/environment/waste-management/recycling/organics/casestudies/cs_1_wrap.pdf

WRAP U.K. (2011, March 22). New report highlights water and carbon impact of wasted food. London: WRAP UK. Retrieved from http://www.wrap.org.uk/content/new-report-highlights-water-and-carbon-impact-wasted-food

WRAP U.K. (2011a). Solutions for the retail supply chain. London: WRAP UK. Retrieved from http://www.wrap.org.uk/content/solutions-retail-supply-chain

WRAP U.K. (2012). Freezing guidance to prevent food waste. London: WRAP UK. Retrieved from http://www.wrap.org.uk/sites/files/wrap/Info%20Sheet%20Freezing%20final.pdf

WRAP U.K. (2014). *Running a whole chain resource efficiency project*. London: WRAP UK. Retrieved from http://www.wrap.org.uk/content/pathfinder-projects

Williams, P., Leach, B., Christensen, K., Armstrong, G., Perrin, D., Hawkins, R., …. Scholes, P. (2011). *The composition of waste disposed of by the UK hospitality industry* (Project code: RES093-00). London: WRAP UK. Retrieved from http://www.wrap.org.uk/sites/files/wrap/The_Composition_of_Waste_Disposed_of_by_the_UK_Hospitality_Industry_FINAL_JULY_2011_GP_EDIT.54efe0c9.11675.pdf

Wylie-Toal, B. (2013, Sept. 13). Food and health care: does local fit? Presentation to *OMAFRA*. Retrieved from http://www.mysustainablecanada.org/attachments/article/222/Local%20Food%20Symposium%20Presentation%20Slides.pdf

Appendix

Table A1: Possible modifications to the *Canadian Consumer Packaging and Labelling Act* (CCPLA) to ensure authority for food waste reduction interventions.

Canadian Consumer Packaging and Labelling Act **(WITH PROPOSED MODIFICATIONS IN BOLD CAPS)**

Packaging requirements established by regulation

- **11.** (1) Where the Governor in Council is of the opinion that there is an undue proliferation of sizes or shapes of containers in which any prepackaged product or class of prepackaged product is sold and that the effect of the undue proliferation of sizes or shapes is to confuse or mislead or be likely to confuse or mislead consumers with respect to the weight, measure or numerical count of a prepackaged product, **[OR CONTRIBUTE TO LUXUS CONSUMPTION OR FOOD WASTE]** the Governor in Council, on the recommendation of the Minister, may make regulations establishing packaging requirements that limit the sizes and shapes of containers in which that prepackaged product or class of prepackaged product may be sold. **[EQUALLY, IF THE RANGE OF SIZES OR SHAPES ENCOURAGES MANY CONSUMERS TO BUY MORE THAN THEY NEED, THEN THE GOVERNOR IN COUNCIL CAN REQUIRE THAT SMALLER SIZES BE USED[A]. THE GOVERNOR IN COUNCIL MAY ALSO PASS REGULATIONS TO ENSURE USE OF NEW PACKING TECHNOLOGIES THAT MINIMIZE FOOD WASTE, SEE PREVIOUS SECTION.]**
- *Marginal note: Advice for establishing packaging requirements*

  (2) For the purpose of establishing packaging requirements for any prepackaged product or class of prepackaged product, the Minister shall seek the advice of at least one organization in Canada of consumers and one organization of dealers in that prepackaged product or class of prepackaged product and may seek the advice of the Standards Council of Canada or any organization in Canada engaged in standards formulation.

[a] Such regulatory amendments could appear under the Processed Products Regulations of the Canadian Agricultural Products Act, http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.%2C%5Fc.%5F291/FullText.html

---

Table A2: possible modifications to the Ontario *Farm Products Sales and Grades Act* to encourage food waste reduction

---

Ontario Farm Products Sales and Grades Act **(WITH PROPOSED MODIFICATIONS IN BOLD UPPERCASE)**

Regulations

2. (1) The Minister may make regulations,

1. designating as a farm product any farm product or a class thereof or any article of food or drink manufactured or derived in whole or in part from a farm product;

2. establishing grades for a farm product;

3. providing for the inspecting, grading, packing and marking of farm products;

4. respecting the buying, selling, advertising, handling, shipping and transporting of farm products **[UNDER THIS PROVISION, THE PROVINCE COULD FORBID BOGOF AND REQUIRE BOGOF-L]**

5. respecting packages for farm products; **[REFLECT CHANGES TO THE CCPLA PROPOSED IN TABLE 3, FOR EXAMPLE, UNDER THE STRUCTURE OF REG. 378 THAT WAS REVOKED IN 2011]**.

6. prescribing the manner in which sellers, transporters and shippers of farm products shall identify, for purposes of grading, individual producer's lots in a shipment;

7. prescribing the manner in which shippers or packers shall make returns and prepare for presentation to the producer the statements of accounts of purchase of farm products and for the investigation of such statements and the transactions represented thereby; **[USE THIS TO FORBID LAST MINUTE CHANGES TO ARRANGEMENTS BY SHIPPERS, PACKERS AND RETAILERS; ADD A CLAUSE TO THE EFFECT THAT ORDER REDUCTIONS WITHIN 24 HOURS CAN ONLY BE PERMITTED BY THE AGREEMENT OF BOTH PARTIES]**

Table A3: Changes to provincial legislation to enable construction of demand-supply coordination structures and mechanisms, with Ontario as an example

---

Under the Ontario *Farm Products Marketing Act* **(PROPOSED CHANGES TO SELECT PROVISIONS IN BOLD UPPERCASE)**[58]

Purpose of Act

2. The purpose of this Act is to provide for the control and regulation in any or all aspects of the producing and marketing within Ontario of farm products including the prohibition of such producing or marketing in whole or in part. R.S.O. 1990, c. F.9, s. 2. **[THE ACT ALSO PROVIDES FOR THE COLLECTION AND ANALYSIS OF FOOD CONSUMPTION**

[58] http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90f09_e.htm

DATA AND THE LINKING OF PRODUCTION, DISTRIBUTION AND MARKETING TO ACHIEVE MORE OPTIMAL FOOD CONSUMPTION AND ITS ASSOCIATED HEALTH IMPROVEMENTS]

7.1.25. providing for the establishment in connection with any plan, of **NEGOTIATING** agencies that may be empowered to adopt or settle by agreement any or all of the following matters:

i. minimum prices for the regulated product or for any class, variety, grade or size of the regulated product,

ii. terms, conditions and forms of agreements relating to the producing or marketing of the regulated product,

[THE ESTABLISHMENT OF VIRTUAL MARKET PLACES FOR THE EXCHANGE OF REGULATED PRODUCTS BETWEEN BUYERS AND SELLERS OF GOODS DESTINED FOR DOMESTIC CONSUMPTION]

[PARTICIPATION OF BUYERS AND SELLERS OF REGULATED GOODS WITHIN THE MARKET PLACE IS MANDATORY.]

Regulations vesting powers in local board

8. (1) The Commission may make regulations vesting in any local board any powers that the Commission considers necessary or advisable to enable such local board effectively to promote, regulate and control the producing or marketing of the regulated product, and, without limiting the generality of the foregoing, may make regulations,

(a) vesting in any local board any or all of the following powers,

(i) to direct and control, by order or direction either as principal or agent, the producing or marketing of the regulated product, including the times and places at which the regulated product may be produced or marketed,

(ii) to determine the quality of each class, variety, grade and size of the regulated product that shall be marketed by each producer,

(iii) to prohibit the marketing of any class, variety, grade or size of the regulated product,

(iv) to determine from time to time the price or prices that shall be paid to producers or to the local board, as the case may be, for the regulated product or any class, variety, grade or size of the regulated product and to determine different prices for different parts of Ontario **[ACCOUNTING FOR OPTIMAL NUTRITIONAL REQUIREMENTS AND DEMAND]**