SUSTAINABLE TO-GO FOOD CONTAINERS

AN INVESTIGATIVE REPORT

BY SPEC'S WASTE COMMITTEE

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GREEN 2 GO
a restaurant waste reduction project

Society Promoting Environmental Conservation

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GLOSSARY OF TERMS

Cradle to cradle: an approach to design that seeks to create products and systems that are not only efficient but also essentially waste free.

Down-cycling: The conversion of waste-materials into lower-quality products which ultimately end up in the landfill, e.g. recycled plastic is mixed with different plastics creating a lower grade plastic that will eventually be un-recyclable

Extended Producer Responsibility (EPR): as an environmental policy, it ensures producers and consumers are physically and financially responsible for post-consumer management of their products in an environmentally safe manner

EPS: Expanded Polystyrene, a closed cell foam which is a type of polystyrene used to make products like the white "clam shell" to-go container packages.

Feedstock: the basic input raw material that is processed and transformed into another product.

Green house gas (GHG): gases (e.g. carbon dioxide, methane and nitrous oxide) that trap heat in the atmosphere and contribute to the greenhouse effect, one of the causes of global warming.

Life Cycle Analysis (LCA): Each product has a lifecycle from carrying it from it's birth to it's death. The LCA is a technique used to determine the Environmental impact within all the stages of the product.

MSW: Municipal Solid Waste, a formal term for a cities' garbage.

PLA: Polylactic Acid or Polylactide, bio-based polymers derived from renewable resources such as corn.

PS: Polystyrene, a synthetic polymer made from a liquid petrochemical.

PSFS: Polystyrene food service (cups, plates, trays, etc).

Up-cycling: The conversion of waste-materials into products which are beneficial and are integrated into another product life-cycle, e.g. composting of organic material into fertilizer

Waste-to-Energy (WTE): the process of burning municipal waste in industrial incinerators to produce energy.

INTRODUCTION

Every year, Metro Vancouver produces enough garbage to fill a line of garbage trucks from Vancouver to the Ontario border, an estimated 1,354,417 tonnes of solid waste. Of this, approximately 55% of the waste generated in our region is being diverted for reuse or recycling[i]. As our regional population increases, the pressures on the waste disposal systems increase too. This results in a need to continue expanding our local landfill at Cache Creek, as well as more waste being incinerated resulting in the planned expansion of further incinerators. Although burning our garbage may reduce the physical space it requires, it releases toxic chemicals into the atmosphere that are harmful to human health and have major impacts on our ozone layer not to mention the health of other living habitat. In light of this growing problem, both municipal and regional governments are setting ambitious goals for increased waste reduction and diversion[ii]. The regional Metro Vancouver authority seeks to increase the diversion rate to 70% by 2015 and 80% by 2020[iii].

Of the over 1 million annual tonnes of waste generated in our region, approximately 25,000 tonnes can be attributed to to-go food containers, or 1% of residential waste.[iv] While this may seem like an insignificant amount by weight, to-go containers are voluminous and prevalent taking up valuable space and often dispersing beyond landfill boundaries. The operations manager of the Noodle Box, estimated to-go container use at 750,000 units annually[v], which is only one of the over 4,000 restaurants in Metro Vancouver[vi]. While it does not constitute a majority of our region's waste, the reduction and greening of to-go container waste has a potential to lower overall waste figures, and perhaps more importantly, reduce our region's environmental footprint and normalize more environmentally friendly behaviour.

Vancouver citizens are aware of the environmental concerns regarding food to-go containers and have expressed their intention to support restaurant efforts to reduce pollution. A survey conducted by the Society Promoting Environmental Conservation (SPEC) revealed that *91% of respondents would support a restaurant that uses environmentally friendly containers and pay extra for a more environmentally friendly container.*

GREEN 2 GO
a restaurant waste reduction project

The collaborative Green 2 Go Project aims to assist Vancouver in its goal of reducing landfill-bound solid waste by working with city restaurants and the public in dialogue and support in reducing to-go container waste. The project will assist and leverage capacity of existing initiatives in Vancouver, linking efforts through a more centralized approach to encourage and assist businesses and consumers in providing or transitioning to fully reusable, compostable or recyclable alternatives. It will establish solutions based on environmental standards, restaurant specific needs and economic considerations. With support from partners, facilitators and volunteers it will then engage with businesses and the public at large to convey problems posed by conventional to-go containers and assist businesses in the adoption of alternatives.

There are a wide range of to-go containers available and currently being used by food service providers in Metro Vancouver. Types include: *polystyrene* (commonly known as Styrofoam), *plastic* (with a wide-range of recycling industry codes); *aluminum, paper*; *biodegradable* (made from various materials) and *reusable* containers (also made of different materials). A full life-cycle analysis of all available containers would provide a clear picture of the most environmentally friendly container, but life-cycle analyses for most commercial products are expensive and not currently available. In its absence, a team of researchers from the SPEC's Waste Committee undertook a review of current information in order to evaluate the relative environmental and economic merits of available to-go container products. As part of SPEC's Green 2 Go Project, this report will explore these six types of containers, outlining production related impacts, the financial costs, and what options for disposal exist in order to assist restaurants with their procurement and disposal options for to-go containers.

KEY CONCEPTS

In order to have a clear understanding of waste management issues, it is crucial to have an idea of what happens to our waste and what the main disposal options are.

WASTE HIERARCHY

The concept of waste hierarchy describes the order of preference of the various disposal options:

Figure 1 - Waste Hierarchy

The earth contains a limited amount of resources. Waste sent to a landfill does not remove it from the planet but merely provides a toxic and inefficient holding ground. Canadians generate almost 1,100 kg of municipal solid waste (MSW) per capita, of which over 75% is sent to the landfill and only 22% is recycled[vii]. The best way to fix this problem is to prevent the amount of waste being sent to the landfill by reducing what is 'waste' through smarter purchasing decisions and recognizing what constitutes waste.

Burning waste, also known as waste-to-energy (WTE), may appear to be an attractive solution for waste disposal as it solves landfill space issues. It is however not very efficient at recovering the energy used to create the product. Only 5% of the energy is recovered and emits both greenhouse gases (GHG) and toxic emissions[viii].

"POLLUTION IS NOTHING BUT THE RESOURCES WE ARE NOT HARVESTING. WE ALLOW THEM TO DISPERSE BECAUSE WE ARE IGNORANT OF THEIR VALUE" – R. BUCKMINSTER FULLER

Currently recycling and composting are the most common ways to decrease waste generation. In terms of resource conservation, recycling is a far better option than disposal or WTE, however, recycling and composting still result in the loss of the energy required to manufacture, transport and collect the product. Recycling also has its limits, mostly for plastic, which when recycled is down-cycled into a lesser grade material. Contamination between different types of plastic is also a barrier – it is estimated that only 10% of BC's plastic waste is actually recycled[ix]. Given the limited benefit of recycling, reduction and reuse are better options than recycling.

Although most efforts have been devoted to recycling, priority should be given to more upstream solutions, reducing waste production and reusing products before recycling to avoid the energy consumption and pollution generated by re-processing and transporting. These two options would require greater public awareness and education, as well as policies and laws to help engage producers to design products with an extended lifespan (easy to reuse and repair). One example of a recommended policy is the ban of single use products and packaging comes as proposed by the Canadian Centre for Policy Alternatives [x].

DEFINITION AND DISCUSSION: BIOPLASTICS, BIODEGRADABLE, AND COMPOSTABLE

With the rise of the "green products" the same terms have been used to describe products with very different environmental characteristics. It is then important to clarify these terms.

BIOPLASTIC

Bioplastic is a term used to describe two really different characteristics: the origin of the resource (bio-sourced) and the end of life of the product (biodegradable or compostable). It can then describe three types of plastics:

- Non-biodegradable or compostable but from renewable resources
- Biodegradable or compostable but from non-renewable resources
- Biodegradable or compostable and from renewable resources[xi]

BIODEGRADABLE OR COMPOSTABLE?

The American Society for Testing and Materials (ASTM) provides the following definitions for these two concepts:

- Biodegradable Plastic - a degradable plastic in which the degradation results from the action of naturally occurring microorganisms such as bacteria, fungi and algae.
- Compostable Plastic - a plastic that undergoes degradation by biological processes during composting, to yield carbon dioxide (CO_2), water, inorganic compounds and biomass at a rate consistent with other compostable materials and leaves no visible, distinguishable or toxic residue.

A biodegradable bioplastic is then not always compostable, whereas a compostable bioplastic is always biodegradable by definition. It is important to note that this degradation is occurs viamicro-organisms, which is different from the degradation of the bioplastics through “Oxo-biodegradation”. This process breaks down the plastic into microscopic fragments through chemical oxidation, which can potentially accumulate and pollute the environment. The complete biodegradation or assimilation by the microorganisms has not yet been proven[xii].

One of the sad truths is that what happens to the product at the end of its life is unpredictable and depends on the user and the facilities available. Hence many are tossed into the landfill regardless if it is biodegradable or compostable.

COMPOSTABILITY, CERTIFICATIONS AND LABELS

The most common certification label in North America is the Biodegradable Products Institute (BPI), which uses the norms ASTM D6400 and ASTM D6868 with the following certification label:

Figure 2 - BPI certification label

Many companies exaggerate their product’s environmental characteristics to increase brand image but the public needs to be careful with misleading declarations. PLA (plastic resin code number 7 category) for example, a corn-based plastic, is theoretically compostable but only in a facility that would use specific temperature and pressure parameters used by few composting operations. This means that, to be actually composted, it would need to be diverted from everything else and composted in a dedicated facility, which is not usually the case.

THE MYTH OF THE LANDFILL

Some people think that materials biodegrade in a landfill and the non-organics items such as plastics will eventually go back to the earth. Unfortunately this is not the case as landfills are designed to minimise degradation:

> “The uncontrolled biodegradation of miscellaneous materials could cause ground water pollution, methane gas pollution and unstable sub-soil conditions. This is why modern landfills have a controlled environment, poor in oxygen and humidity, causing organic matter to mummify rather than decompose[xiii].”

In fact, in a report on modern landfills, the Environment Industry Plastics Council describes how excavations have uncovered newspapers that are still readable after almost 40 years[xiv].

Composting, on the other hand, is the process of *controlled* biodegradation **outside** a landfill. By carefully controlling the feedstock (source-separated, mixed organics), and controlling the process (moisture content, oxygen levels), composters transform biodegradable materials into useful products that are used in farming, gardening and soil conservation, a strong example of up-cycling

LEGISLATIVE LANDSCAPE

There are two important updates coming in 2014 and 2015 that will affect procurement and disposal decisions for restaurants in the lower mainland: a ban of organic material in the waste stream from all sources in Metro Vancouver, and the inclusion of packaging and printed paper into the BC Extended Producer Responsibility (EPR) recycling landscape.

The organics ban, enforced by Metro Vancouver, will be phased in during 2015 and will exclude food scraps, food-soiled paper and yard waste from all sources of garbage collection. Upon implementation all restaurants will be responsible for separating these organic materials from their garbage. It is recommended that restaurants begin assessing the needs of their organization and prepare for the implementation of the organics ban. More information can be found on the Metro Vancouver website on proper donation, composting or transporting options for restaurants[xv]. Not complying with these regulations could result in fines in addition to possible negative press and backlash from customers for non-compliance[xvi]. Restaurants who adopt early will benefit from increased brand reputation as a leader[xvii]. Studies also show that businesses that are on top of regulations have higher employee retention rates and better recruitment of top talent[xviii].

In May 2014, the responsibility for collecting and processing packaging and printed paper (PPP) will shift from local governments to industry - defined as brand owners and first sellers. These companies and organizations will be required to pay for the packaging and printed paper that they put in the market to fund the collection and processing of this waste stream. This applies to a large list of to-go packaging currently used by restaurants[xix]. While no costs will be directly applied to restaurants, the cost of packaging can be assumed to increase upon implementation as producers pass on the costs. Furthermore Multi-Materials British Columbia, the association formed to run this programme, plans to reward producers of recyclable PPP through reduced costs whilst disincentivizing those who supply PPP with no end markets with higher fees. Essentially cheap, non-recyclable packaging will become more expensive to purchase in BC after May 2014.

THE EFFECTS OF THESE MEASURES WILL CHANGE HOW RESTAURANTS DISPOSE OF THEIR WASTE AND ON THE TYPE OF PACKAGING THEY CHOOSE. RESTAURANTS CAN TAKE A PRO-ACTIVE APPROACH TO THESE AND FUTURE REGULATORY CHANGES BY ADOPTING SMARTER, GREENER MEASURES IN THEIR OPERATIONS BY PROVIDING COMPOST BINS AND CHOOSING BETTER PACKAGING. THE REST OF THIS REPORT IS INTENDED TO PROVIDE THE INFORMATION NECESSARY FOR RESTAURANTS TO DECIDE WHICH TYPES OF PACKAGING BEST SUITS THEIR NEEDS AND PROVIDE ADDITIONAL RECOMMENDATIONS FOR REDUCING GARBAGE GENERATION.

TYPES OF CONTAINERS

The following sections will discuss the production and disposal of the six most available types of packaging: polystyrene, plastic, aluminum, paper, biodegradable and reusable.

POLYSTYRENE (STYROFOAM)

The most common food to-go container used today is made of expanded polystyrene (EPS) usually referred to by its commercial name Styrofoam™. Polystyrene is widely used in food packaging for its light weight, good thermal insulation, shock absorption properties and affordable cost[xx,xxi], but its environmental burden is so high that its use for food packaging has been banned in more than 100 cities in the US[xxii,xxiii].

PRODUCTION

Polystyrene (PS) is formed by the polymerization of a styrene monomer, obtained from fossil fuel products: ethylene and benzene[xxiv,xxv]. The two main types of polystyrene are: high-impact (or rubber-modified PS) and general-purpose (also known as crystal or GPPS). Expandable (or "expanded") polystyrene EPS is the result of adding a blowing agent to GPPS[xxvi]. To-go food containers are made of GPPS, both in its clear and expanded form.

Since PS products are extremely light, their low mass to volume ratio gives them an advantageous position when calculating environmental impacts such as carbon footprint[xxvii].

When comparing PS to paper, they are found to have a higher environmental footprint. A study comparing paper and polystyrene egg-packaging showed PS reduces toxic metal waste but consumes more energy, and releases more air-pollutants (seven times more NO_x and 16 times more SO_x) and has higher acidification potential than equivalent recycled paper packaging[xxviii]. Their conclusion is consistent with other studies that have found PS packaging requires five times more fossil fuel energy than the corrugated board equivalent (see appendix II)[35].

DISPOSAL

EPS has a very low density, making it very expensive to recycle. It costs more than $1,000 USD per tonne, over 11 times the cost of glass recycling[xxix]. For that reason it is not economical to collect[xxx] for recycling and thus it is generally sent to landfills where it "*takes up to three times the amount of space as regular garbage*" and does not biodegrade[xxxi]. The Toronto Blue Box program has twice tried and failed to include ESP in the program due to the high costs[xxxii].

There are markets for ***clean*** EPS, and some Canadian municipalities are currently recycling block polystyrene (used for packaging)[xxxiii xxxiv]. EPS to-go containers however have the complication that they are contaminated with food and hence need to be scrubbed before recycling. For that reason only 0.2 % are actually recycled[xxxv, xxxvi, xxxvii, xxxviii]. The foam industry[xxxix,xl] claims that foam recycling can be made profitable by densification procedures, however this does not address the contamination issue.

Another consequence of EPS's low density is that they are more likely, than other materials, to be blown away, ending up in rivers and oceans causing damage to ecosystems. According to a California Department of Transportation study, EPS represented 15% of the total volume of litter recovered from the storm drains[xli]. A study of the debris on British Columbia's coastal waters and its potential effects on marine mammals species, reports that "*Styrofoam was by far the most common type of debris we observed*"[xlii].

To sum up, EPS recycling in general is difficult and expensive, and food soiled EPS recycling is unviable. In addition, recycling is also often not a closed loop system; resulting in recycled EPS being down-cycled into items that ultimately will end up in landfill[xliii].

IMPACTS ON HUMAN HEALTH

Concerns over health effects of polystyrene packaging on human health come from two facts: evidence that styrene exposure can have detrimental effects on human health and evidence that styrene can leach from packaging[xliv,xlv], especially when content is high in fat or exposed to high temperatures[xlvi]. The American Cancer Association includes styrene as a substance "reasonably anticipated to be human carcinogen"[xlvii]. However, in a 1993 report Health Canada concluded that *"on the basis of the available data […] the concentrations of styrene present in the Canadian environment do not constitute a danger in Canada to human life or health.*" Thus, there is some concern over the toxicity of styrene in food containers, but it is estimated to cause minimal harm.

CONCLUSIONS

- PS depends on fossil fuels as a raw materials input.
- The production of single use PS to-go containers has high energy costs but is otherwise comparable to other materials with regards to environmental impact.
- The major environmental burden is from disposal since recycling rates of food soiled PS packaging are negligible and most food containers end up in landfills where they take up much more space than other materials.
- Effects on human health have not been confirmed but certainly negative effects on wildlife are of special concern.

PLASTIC

At first glance plastic materials seem like the most convenient solution for to-go food containers: they are light, durable, water resistant, allow visibility of content, and are even microwavable in some cases[xlviii, xlix]. In addition, they tend to be cheaper than other materials[l]. Unfortunately, plastic's apparent advantages fade out when their production and disposal phases are considered, both of which substantially increase a container's environmental burden.

PRODUCTION

Plastics are made of long chains of hydrocarbon fused together in structures called polymers[li] derived from petrochemicals. Their production begins in oil refineries, where a distillation process separates heavy crude oil into lighter substances[lii]. One of these fractions, naphtha, is the crucial element for the production of ethylene, the precursor of many polymers[liii]. Polymers are melted and moulded, pelletized or flaked into products called resins [liv].

There are two main categories of plastics: thermosets, that once solidified cannot be moulded again, and thermoplastics, which can be melted and reused as raw materials for new products[lv,lvi]. Food to-go containers are made from thermoplastics[lvii].

Plastic manufacturers often argue that plastic resins make use of by-products of the oil industry[lviii,lix] but their production still depends on large amounts of fossil fuels and water that could be preserved or used for other applications. In 2010, 191 million barrels of liquid petroleum gases and natural gas liquids were used for the plastic and resins industry in the US alone[lx]. According to the US Environmental Protection Agency this represents 0.43 metric tons CO_2/barrel for a total of 82 million tons CO_2[lxi,lxii].

DISPOSAL

Most people feel good about using plastics as long as they can be recycled[lxiii], and the plastic industry often highlights recyclability as a beneficial environmental feature of plastic packaging [lxiv, lxv, lxvi]. Recycling certainly plays an important role in diverting plastics from landfill[lxvii,lxviii] and the use of recycled resins effectively reduces demand for virgin materials and GHG emissions[lxix]. For instance producing one tonne of clear PET (see resin description in Table 1) from recycled, rather than virgin, material uses 16-59% less energy and produces 90% less CO_2 emissions[lxx]. However, improper sorting and contamination issues, together with municipalities' collection limitations, technical difficulty in separation of multilayer materials and variable market prices, make recycling economically unviable for many plastic products[lxxi,lxxii]. Furthermore, the reprocessing of plastics occurs at temperatures high enough to destroy microorganisms, but not sufficient to pyrolize organic contaminants, therefore post-consumer recycled plastics are not generally used in applications that involve food contact, [lxxiii] causing the original material to be down-cycled[lxxiv].

Traditional plastics (codes 1-7 from Table 1), are chemically engineered to be durable and resistant, and they are expected to take long time to degrade[lxxv,lxxvi] although the exact time is uncertain. What we do know is that when plastic objects are exposed to oxygen, sunlight and abrasive conditions for long enough periods they do break into small pieces[lxxvii] but this decomposition rate is reduced due to both the addition of antioxidants [lxxviii] and landfills' anaerobic conditions[lxxix,lxxx].

Unfortunately not all plastics end up recycled or in landfills. Food to-go containers, wrappers and plastic cutlery make up to 17% of the plastic recovered from beach clean-ups worldwide [lxxxi]. Plastic debris accumulation in the water column is more evident in areas where ocean currents and atmospheric

Table 1 – Plastic Resin Codes

Symbol	Polymer name	Sample uses
1	Polyethylene terephthalate (PET)	Soft drink bottles
2	High-density polyethylene (HDPE)	Detergent bottles, children's toys
3	Polyvinyl chloride (PVC)	Water pipes, medical equipment
4	Low-density polyethylene (LDPE)	Plastic bags, 6-pack rings
5	Polypropylene (PP)	Yogurt containers, screw-on lids
6	Polystyrene (PS)	Plastic cutlery, coffee cups
7	Other (incl. bioplastics)	

conditions cause zones of convergence, like the North Pacific central Gyre, where it is estimated that plastics outweigh plankton, by a ratio of 6 to 1[lxxxii].

Many of those plastic fragments and resin pellets are mistaken for food by marine fauna [Photograph 1[lxxxiii]][lxxxiv],[lxxxv]. A 2010 study found that 35% of planktivore fishes sampled in North Pacific Central Gyre had ingested plastic[lxxxvi]. Fish are not the only organisms affected. According to the United Nations Environmental Program, at least 267 species have been reported to suffer from entanglement or ingestion of plastic debris[lxxxvii] and some species seem particularly vulnerable to increased plastic consumption. A study from the University of Queensland in Australia found that green and leatherback turtles are eating more plastics than ever before and ingesting more plastic than other materials[lxxxviii]. British Columbia's marine mammals[lxxxix] and birds are no exception to this trend, 67 beached seabirds collected between 2009 and 2010 from the coasts of B.C., Washington and Oregon revealed that 93% of them had bellies full of plastic[xc]. Ingested plastic debris physically obstructs animal's feeding and digestive processes, and this is particularly the case in small chicks which are unable to regurgitate the plastics fed by their parents[xci].

Figure 3– Jordan, C. (2009). The Great Pacific Garbage Patch.

Plastic debris absorbs toxic persistent organic pollutants present in the seas[xcii] creating "toxically enriched" particles. When ingested, these result in the pollutants accumulating in the animal's tissues and, through a process called biomagnification, their concentration increases as it moves up in the food chain, reaching maximum levels in predatory fish and marine mammals[xciii], some of which are later consumed by humans.

To sum up, our research shows that the use of plastic to-go containers increases the likelihood of damage to wildlife if not disposed of properly, something evidence has shown happens more often than expected.

CONCLUSION

- The production of plastic resins and containers depends on fossil fuels whose combustion contributes to GHG emissions and eventually global warming.
- If a business decides to use plastic to-go containers we strongly recommend they make sure to avoid codes PVC (#3) and PS (#6), which cannot be recycled in our municipality (see Appendix 3).
- To ensure proper disposal after use, restaurants using plastic to-go containers should only offer products with clearly labeled resin codes so the final user or customer can recycle or dispose responsibly.
- We encourage businesses to educate and guide their customers about how to properly dispose of their to-go containers.

ALUMINUM

Aluminum is a lightweight metal derived from bauxite ore. It is used prolifically due to its high barrier to moisture, air, odours, light and microorganisms whilst also being highly malleable and flexible[xciv]. Generally speaking, it is an expensive container option relative to other materials and involves a high GHG emissions factor.

PRODUCTION

Bauxite is the mineral form of aluminum abundantly found in the earth's crust. The extraction process is both energy intensive and destructive. In order to extract bauxite from the earth, vegetation and topsoil are removed to expose the mineral. Next, alumina – the aluminum oxide material found in bauxite – is extracted from bauxite through digestion, clarification, precipitation, and calcination. Finally, the alumina is smelted at extremely high temperatures to separate the oxygen from the aluminum. The aluminum is then casted into ingots which are used to manufacture a wide range of aluminum products[xcv]. This aluminum is then made into an alloy with magnesium to create packaging products including to-go containers[xcvi].

Each step in the production chain of aluminum requires a tremendous amount of energy to harvest, transport, refine, smelt and cast. Table 2[xcvii] outlines the tonnes of carbon emissions emitted at each stage of production.

Table 2

	Bauxite	Refining	Anode	Smelting	Casting
Total (kg) of CO_2 equivalent per tonne of Aluminum	248	1908	374	9789	368

The carbon footprint of aluminum production is over eight times that of paper or plastic[xcviii]. Thus, the production of aluminum from raw materials has the greatest environmental impact per unit of packaging relative to all other materials presented in this report.

DISPOSAL

Despite the large amount of energy required to produce aluminum, its properties make it excellent for recycling which reduces the need for raw materials. Making an item from recycled, rather than raw aluminum requires 90% less energy, thus reducing the overall environmental impact[xcix]. Furthermore, given that aluminum can be melted and recycled repeatedly, without any loss of structure or properties (i.e. it is not down-cycled)[c], it has high economic value which can lead to a greater incentive to recycle.

CONCLUSION

Aluminum packaging carries significant environmental impacts in its production from raw materials whilst also being a relatively expensive packaging. The benefits of using aluminum packaging reside in its flexibility, surface resilience and malleability. Aluminum packaging becomes an attractive option when it is made from recycled aluminum, given the lower total amount of energy required to produce the product.

PAPER

Use of paper foodservice products has been favoured because paper and paperboard packaging is thought to be the more environment friendly option than plastic packaging[ci]. A study comparing recycled paper egg packages with polystyrene showed that recycled paper container has overall less negative environmental impact[cii] but more heavy metal and solid wastes[ciii].

PRODUCTION

Paper and paperboard are manufactured using a renewable resource, wood. An intertwined network of cellulose fibre is manufactured from wood by sulphate and sulphite to make sheet materials[civ]. Then the fibres are pulped and/or bleached and treated with chemicals and strengthening agents to manufacture paper and paperboard products[cv]. Paper is usually treated, coated, laminated, or impregnated with ingredients like waxes, resins, or lacquers when it's used for food packaging, where it comes in direct contact with food, to enhance protection and function[cvi].

Paper and paperboard production can impose negative environmental impact throughout its production. The paper mill industry is one of the worst polluters of the environment according to the U.S. Environmental Protection Agency[cvii]. According to the statistics by the Worldwatch Institute, millions of pounds of highly toxic chemicals like toluene, methanol, chlorine dioxide, hydrochloric acid, and formaldehydes are released into water and air by paper making plants around the world[cviii].

Recycled paper does have a lower footprint, requiring 28-70% less energy than virgin paper depending on the paper grade, process, mill and distance to markets[cix]. Disposable paper to-go food containers usually do not contain recycled paper[cx], although there has been a recent increase in availability thanks to increased awareness and market demand[cxi]. With increasing demand for more environmentally friendly paper products, there are many paper foodservice product manufactures that use recycled content[cxii]. For example, Fold-Pak produces their paper containers from 100% recycled paper with 35% or more post-consumer recycled paper. Another company, Solo, also produces a line of recycled content drink cups[cxiii].

DISPOSAL

The majority of disposable foodservice products cannot be recycled or composted because they are coated with a plastic lining[cxiv]. Alternatively, recently many manufacturers have been using either a wax or PLA coating for their paper products so the products can be composted[cxv].

In landfills, if paper decomposes it does so anaerobically emitting CO_2, methane, and ammonia[cxvi]. The resin coatings of coated paperboard products release fossil CO_2 when burned in Waste-To-Energy combustion facilities.

CONCLUSION

Paper foodservice products are a better choice than plastic or polyethylene food service products when considering environmental impacts. Paper foodservice products made from recycled content are a more environmentally friendly choice. However, paper production itself imposes significant damages to the environment.

BIODEGRADABLE AND COMPOSTABLE

Biodegradable polymers can be made from a variety of materials such as: plants, industry waste or microbial source materials[cxvii]. They are made from renewable resources, unlike conventional plastics, which are made from fossil fuels (coal, oil, and natural gas)[cxviii]. Consequentially they require less energy to make[cxix] and at the end of life can degrade into CO_2 and water[cxx]. As consumers become more environmentally conscious, they are looking for more eco-friendly materials rather than Styrofoam[cxxi]. Bagasse is a great example of a PLA product that is made from the fibrous remains of sugarcane stalks[cxxii]. Bagasse, being made from a waste renewable resource and being compostable, is therefore, one of the leading alternative materials to Styrofoam for food service products[cxxiii]. Bagasse food service products can be put in the microwave, frozen, and withstand up to 180 degrees Celsius[cxxiv] making them a very viable alternative.

The switch to biodegradable materials cannot solve all solid waste management issues because the presence of mixed or modified polymers in the recycling stream can get complicated[cxxv]. Furthermore, biodegradable products cannot generally biodegrade in landfills due to the absence of oxygen[cxxvi].

Over the years, the price of bioplastics made with renewable resources has been decreasing and it could possibly be comparable to traditional material prices in some areas in near future[cxxvii].

PRODUCTION

Traditional equipment can be used to produce starch-based materials with very little or no modifications[cxxviii]. PLA is made through the polymerization of lactic acid derived from the fermentation of starch[cxxix]. Starch-based materials are made from slightly modified starch, either alone or combined with natural or synthetic biodegradable polymers[cxxx]. They are currently available in biodegradable and compostable films and are mainly made of restructured starch completed with thermoplastic polymers[cxxxi].

PLA manufacturing reduces demand for petroleum products and emits less air pollution than conventional plastics [cxxxii]. However, there are agricultural issues associated with PLA production.[cxxxiii] For example of all U.S. crops, corn uses the most nitrogen fertilizer, herbicides, and insecticides[cxxxiv], which are all derived from petro-chemicals. Furthermore, nitrogen can leak into streams and rivers causing soil erosion and water pollution[cxxxv].

PLA production varies vastly, from the feed-stocks being genetically modified corn to waste the by-product of sugarcane[cxxxvi]. Hence there is a lot of controversy around the impacts of PLA. We will use Bagasse as an example to illustrate the lifecycle process. To make Bagasse, sugarcane is harvested and crushed using a series of large rollers[cxxxvii] to extract the juice used to make sugar[cxxxviii]. The wet Bagasse is the fibrous stalk that is left behind[cxxxix]. This is pressed, disinfected and dried into paperboard that is processed to biodegradable foodservice products[cxl,cxli].

Disposable foodservice products made with Bagasse can be lined with a cornstarch based PLA film[cxlii]. A clear, thin sheet of PLA lining creates barrier for moisture and grease to protect the food container and make the container suitable for all kinds of food[cxliii].

Bagasse requires less water for its production than Styrofoam, paper and recycled paper[cxliv]. It also emits less CO_2 during the process.[cxlv] However, China is currently the only place where Bagasse is being produced for commercial use[cxlvi] resulting in coal powered energy and high transport costs that cannot be ignored[cxlvii].

DISPOSAL

There currently is not enough data available on the disposal, incineration or recycling of PLA products[cxlviii].PLA biodegrades into CO_2 and water in less than 90 days under a controlled composting environment[cxlix]. In order for biodegradable products to degrade, they requires a commercial composting facility and will not break down in home composting systems[cl]. This is where PLA has limitations, due to the lack of industrial-grade composting facilities available for PLA.[cli] Therefore, despite the fact that PLA is more environmentally friendly material, it is highly likely that the majority will still end up in landfill and there is no proof that PLA will degrade faster or more thoroughly than conventional plastic[clii].

Furthermore, consumers must be aware which products are biodegradable because PLA can cause problems if they enter conventional plastic recycling streams[cliii]. Therefore for successful disposal of PLA products, they will require their own code and mechanisms for sorting to ensure they end up at commercial composting[cliv].

On the bright side, NatureWorks, LLC, which manufactures PLA from corn sugar, has been looking at recovering lactic acid by hydrolyzing the polymer after the original use to approach the cradle-to-cradle objective[clv].

Compostable fiber containers offer the advantage of convenient disposal together with food scraps and food soiled paper in green bins[clvi], precisely the kind of bin that is becoming more ubiquitous in Vancouver given the ban on compostable organics from the landfill by 2015[clvii]. To add to customer's convenience, some of compostable containers have been reported to degrade in home composting systems in less than two months.[clviii,clix]

CONCLUSION

PLA products are more eco-friendly than widely available conventional plastics, so long as they are properly disposed of. Due to their comparable performance, PLA food service products have the potential to replace conventional Polyethylene Terephthalate (PET) and Polystyrene (PS). However, PLA to-go containers have limited tolerance for hot food or beverages which may be a limitation for some restaurants. Furthermore, industrial-grade composting facilities are needed for proper disposal of PLA products along with its own code and mechanisms for sorting.

Currently the word biodegradable on a product is not tightly regulated and doesn't mean much.[clx] There are no stipulations around how long or whether or not there will be toxic residues[clxi] Compostable, in contrast, stipulates that they are capable of completely breaking down in a compost site as a part of an available program[clxii] and leave no toxic residues. Compostable materials are therefore better for our soil, and ultimately for our health[clxiii].

REUSABLE

The most environmentally friendly type of container is one that can be used many times over. Each time a reusable container is used it reduces demand for single-use containers – be they polystyrene, paper, plastic or aluminum. Therefore the more often a reusable container is chosen over a single-use one, the smaller the relative impact of that container is.

Only certain types of containers are reusable, such as glass, metal and the stronger types of plastic (e.g. #2 HDPE) given the need to rinse, clean and dry the container before being used again. The same environmental issues are associated with these materials, but if used multiple times, their per-use impact is significantly lower.

The problem with reusable containers is who provides them. A customer can bring in their own containers, requiring foresight and effort on their behalf, which generally speaking is not something most customers currently do. However, there are options for restaurants to incentivize this habit, offering a discount or complimentary item to those who remember their reusable container, thereby reducing the cost of containers to restaurants and container waste.

Alternatively, a number of food trucks, restaurants and cafeterias are implementing reusable container programs which are provided by the vendor, not the consumer. For example the "Tiffin Project"[clxiv] right here in Vancouver, the "Go Box" program in Portland[clxv], the "Bizee Box"[clxvi], and the "Go Green Container Exchange"[clxvii] amongst others are initiatives that create a deposit system for to-go containers that are returned, cleaned and re-used. This is an option that needs to be tested and explored further, but one that offers the greatest potential for reducing the impact of the entire production cycle of single-use containers whilst also reducing the amount of container waste sent to the landfill.

CONCLUSION

In the context of upcoming legislation changes to ensure higher diversion rates from landfills, all restaurants in Vancouver will have to reconsider and strengthen their waste reduction strategies and make sure that their to-go food containers are in line with the City's goals and visions. In addition to being enforced by authorities, these changes will also be expected from consumers, who are aware of their impact and willing to support more environmental friendly strategies. Restaurant managers have a wide range of materials to choose from to adapt to these changes.

The research conducted for this report shows that no material is perfect and all will impact the environment in different ways, but there is certainly a gradient of environmental burdens to be balanced with financial costs.

The Society Promoting Environmental Conservation, with the goal of reducing to-go container impact and waste, ranks the following container options generally (recognizing that there are many different restaurant needs and situations):

- We encourage restaurants to provide incentives to customers that bring their own reusable containers.
- We recommend restaurants to consider switching to compostable containers even if it means asking customers to incorporate the additional costs.
- The use of plastics is not recommended as their recycling rates are considerably low and the production impact is high, but if necessary restaurants should purchase plastic with resin codes 1 or 2
- Even though Styrofoam containers are currently the cheapest available option, there is no responsible way to dispose of food soiled polystyrene containers in Vancouver. Styrofoam carries prolific and persistent end-of-life management issues so we strongly discourage their use and suggest their substitution by materials that can be effectively degraded or composted.

The following table provides a snapshot of the relative rankings on a scale from very bad (3 frowning faces) to very good (3 smiling faces) of each type of container against their cost, production impact, disposal options and any health concerns:

Type	Cost	Production	Disposal	Health Concern
Polystyrene	$	☹	☹☹☹	☹☹
Plastic	$$	☹	☹	☹
Aluminum	$$$	☹☹☹	☺☺☺	☺
Paper	$$	☹☹☹	☺	☺
Biodegradable	$$$$	☺	☺☺	☺
Reusable	$	☺	☺	☺

APPENDICES

The following is a summary of some key tables that provided some insight into this report.

APPENDIX I

This table highlights some of the properties, environmental issues and cost for packaging materials from Marsh, Kenneth, and Betty Bugusu. "Food packaging—roles, materials, and environmental issues." *Journal of food science* 72.3 (2007): R39-R55.

	Product characteristics/food compatibility		Consumer/marketing issues		Environmental issues		
Material	Advantages	Disadvantages	Advantages	Disadvantages	Advantages	Disadvantages	Cost
Glass	• Impermeable to moisture and gases • Nonreactive (inert) • Withstands heat processing	• Brittle and breakable • Needs a separate closure	• Transparent, allows consumer to see product • Can be colored for light-sensitive products	• Poor portability: heavy and breakable • Relatively difficult to decorate	• Reusable • Recyclable • Often contains recycled content	• Heavy and bulky to transport	• Low cost material but somewhat costly to transport
Aluminum	• Impermeable to moisture and gases • Resistant to corrosion • Withstands heat processing	• Cannot be welded • Limited structural strength	• Easy to decorate • Lightweight • Good portability, lightweight, and not breakable	• Limited shapes	• Recyclable • Lightweight • Economic incentive to recycle	• No disadvantages in rigid form • Separation difficulties in laminated form	• Relatively expensive but value encourages recycling
Tinplate	• Impermeable • Strong and formable • Resistant to corrosion • Withstands heat processing	• Can react with foods; coating required	• Easy to decorate	• Typically requires a can opener to access product	• Recyclable • Magnetic thus easily separated	• Heavier than aluminum	• Cheaper than aluminum
Tin-free steel	• Strong • Good resistance to corrosion • Withstands heat processing	• Difficult to weld, requires removal of coating • Less resistant to corrosion	• Easy to decorate	• Typically requires a can opener to access product	• Recyclable • Magnetic thus easily separated	• Heavier than aluminum	• Cheaper than tinplate
Polyolefins	• Good moisture barrier • Strong • Resistant to chemicals	• Poor gas barrier	• Lightweight	• Slight haze or translucency	• Recyclable[a] • High energy source for incineration	• Easily recycled in semi-rigid form but identification and separation more difficult for films	• Low cost
Polyesters	• Strong • Withstands hot filling • Good barrier properties		• High clarity • Shatter resistant		• Recyclable[a,b]	• Easily recycled in rigid form but identification and separation more difficult for films	• Inexpensive but higher cost among plastics
Polyvinyl chloride	• Moldable • Resistant to chemicals		• High clarity		• Recyclable[a]	• Contains chlorine • Requires separating from other waste	• Inexpensive
Polyvinylidene chloride	• High barrier to moisture and gases • Heat sealable • Withstands hot filling		• Maintains product quality		• Recyclable[a]	• Contains chlorine • Requires separating from other waste	• Inexpensive but higher cost among plastics
Polystyrene	• Available in rigid, film, and foam form	• Poor barrier properties	• Good clarity		• Recyclable[a]	• Requires separating from other waste	• Inexpensive
Polyamide	• Strong • Good barrier properties				• Recyclable[a]	• Requires separating from other waste	• Inexpensive but higher cost among plastics
Ethylene vinyl alcohol	• High barrier to gases and oils/fat	• Low moisture barrier/ moisture sensitive	• Maintains product quality for oxygen-sensitive products		• Recyclable[a]	• Requires separating from other waste	• Inexpensive when used as thin film
PLA	• Biodegradable hydrolysable				• Recyclable[a,c]	• Requires separating from other waste	• Relatively expensive
Paper & paperboard	• Very good strength to weight characteristics	• Poor barrier to light • Recycled content makes it unsuitable for food contact material	• Low-density materials • Easily decorated • Efficient, low cost protection	• Moisture sensitive, loses strength with increasing humidity • Tears easily	• Made from renewable resources • Recyclable[b]		• Low cost
Laminates/co-extrusions	• Properties can be tailored for product needs		• Flexibility in design and characteristics		• Often allows for source reduction	• Layer separation is required	• Relatively expensive but cost effective for purpose

[a]All thermoplastics are technically recyclable and are recycled at the production environment, which contributes to lower cost. As inexpensive materials, postconsumer recycling competes with ease of separating and cleaning the materials.
[b]Recycled extensively for nonfood product uses.
[c]Can be broken down to monomer level and reprocessed.

APPENDIX II

The following table displays the environmental impacts per kg of material throughout the life-cycle as calculated by Eco-Invent, a non-profit association that supplies life cycle inventory data:

	pH (kg)	CO2e (kg)	Eutro NOx (kg)	Eutro PO4 (kg)	Fresh Aq Tox	Freshwater Sed Tox	Human Toxicity (kg 1,4-DCB-Eq)	Ionising Radiation (DAYLs)
Aluminum	0.13447	17.00634	0.052914	0.03573	12.84107	28.998981	42.65621	1.57979E-08
Beverage carton	0.0012	0.17817	0.001002	0.000268	0.033808	0.071886017	0.049356	5.4964E-10
Corrugated board	0.006771	1.377325	0.005347	0.003022	0.412386	0.89034918	0.677072	2.62492E-09
EPS	0.011295	3.4955	0.006769	0.001182	0.108824	0.26100251	0.275373	2.27098E-10
Folding box board (FBB)	0.007749	1.176777	0.004634	0.00194	0.250084	0.52960343	0.37636	3.45472E-09
HDPE	0.007185	2.0573	0.004801	0.00065	0.04278	0.099003166	0.045266	2.10768E-10
HIPS	0.012647	3.614833	0.0077	0.001039	0.10959	0.26467014	0.228397	2.2046E-10
LDPE	0.006404	1.96097	0.004459	0.000586	0.032706	0.075258686	0.042873	2.08159E-10
PP	0.006911	2.090491	0.004861	0.000783	0.038842	0.089886213	0.043966	2.07682E-10
Solid Bleach Board (SBB)	0.011117	1.482977	0.008824	0.003235	0.326485	0.70227412	0.680622	4.73427E-09

	Land Use	Mar Aq Tox	Marine Sed Tox	Smog High (kg)	Smog Low (kg)	O3-Dep (kg)	Terrestrial Toxicity (kg 1,4-DCB-Eq)	Energy CED Fossil (MJEq)	Energ CED Nucle (MJE
Aluminum	0.373102	46.37644	51.01127	0.007572	0.004479	5.34973E-07	0.004454	171.6221	6.768
Beverage carton	0.03033	0.137695	0.147921	4.73E-05	2.36E-05	1.03109E-08	0.0001361	2.509023	0.2514
Corrugated board	1.957925	1.526313	1.675249	0.000351	0.000233	9.95212E-08	0.0014093	17.73723	1.2558
EPS	0.009401	0.458804	0.562927	0.000699	0.000435	6.54541E-08	7.349E-05	87.0826	3.7297
Folding box board (FBB)	3.430417	1.003395	1.059401	0.000386	0.000192	5.56782E-08	0.0009364	14.23011	1.7468
HDPE	0.008234	0.161529	0.191265	0.000647	0.00062	7.95763E-09	3.123E-05	73.16851	4.8759
HIPS	0.00893	0.441276	0.546578	0.000767	0.000468	9.47423E-09	6.221E-05	86.0446	3.4722
LDPE	0.008084	0.128551	0.150955	0.000351	0.000222	7.82938E-09	2.752E-05	72.02595	3.703
PP	0.008016	0.147796	0.175676	0.000449	0.000352	7.70779E-09	2.856E-05	71.9967	4.2842
Solid Bleach Board (SBB)	13.35627	1.539094	1.668861	0.000553	0.000367	9.79626E-08	0.0011641	18.61085	2.2856

APPENDIX III

Description of the Society of the Plastics Industry Resins codes and their use:

Code	1 PETE	2 HDPE	3 V	4 LDPE
Resin name	**Polyethylene Terephthalate**	**High Density Polyethylene**	**Polyvinyl chloride.**	**Low Density Polyethylene**
Plastic family	Polyester	Polyolefin	Polyvinyl chloride	Polyolefin
Description	Clear or coloured, light, resistant, brittle.	Natural milky white color or opaque coloured. Strong, durable.	Strong, rigid, durable.	An inexpensive soft plastic.
Products that commonly use it	Soft drink bottles, cups, clamshells, jars	Juice and milk jugs, shampoo laundry jars, carrier bags, cereal box liners, bottle caps	Cartons, blister, clam packs. films, blow molded jars, and flexible plastic tubes	Freezer and carrier bags, bottles, films, caps, flexible tubes, jars and trays sealed with film.
Used in to-go containers?	Yes	Not commonly	Shouldn't be. But has been used to pack bakery items	Not commonly
Reusable	Not recommended	Very	No	Only in bag form.
Recyclable in Vancouver?	Yes. Contaminants: Non-PET shrink labels, PVC, PS, PLA opaque or unusual coloured- PET, and copolymers(PET-G), Oxo-biodegradable polymers.	Yes. Contaminants: PVC, PS, oxobiodegrdable products.	No. PVC is a contaminant for other resins recycling.	Officially yes. Difficult in practice. Contaminants: PVC,PS.
Compostable	No	No	No	No
Health concerns	Not reported	Not reported	Yes	Not reported
Compostable/ Bio-degradable	No	No	No	No

Code	5 PP	6 PS	7 OTHER
Resin name	**Polypropylene**	**Polystyrene**	**Other. May include LCA or Polycarbonate (PC)**
Plastic family	Polyolefin	Styrene	Several.

Description	Rigid, resistant to high temperatures	Available in 2 forms: Rigid (clear) or expanded foam (Styrofoam)	A mix of resins Properties vary, LCA can look quite similar to PET.
Products that commonly use it	Re-sealable tops, bottles, lids, pumps, rigid packages, pouches, flexible tubes, jars and bags.	Insulation, electronics protective packaging food to-go containers	Baby bottles, cooler bottles, car parts.
Used in to-go containers?	Yes. Usually the microwavable kind.	Yes	Could be (LCA)
Reusable	Very	No.	Not recommended
Recyclable in Vancouver?	Yes. Contaminants: PVC,PS.	No	No; Tend to be contaminants in plastic recycling.
Compostable	No	No	Yes
Health concerns	Not reported	Suspected but not confirmed	Some may contain BPA
Compostable/ Bio-degradable	No	No	Only if it's LCA

Sources:

- Aldridge, S., & Miller, L. (2012). *Why Shrink-wrap a cucumber: The Complete Guide to Environmental Packaging*. London: Laurence King Publishers.
- City of Vancouver. (2013). *What goes in the recycling bin?* Retrieved from http://vancouver.ca/home-property-development/what-goes-in-recycling-bins.aspx
- EarthEasy. (2012, May 2). Plastic by the Numbers [Web log post]. Retrieved from http://eartheasy.com/blog/2012/05/plastics-by-the-numbers/
- Lee, M., Legg, R., Maxwell, S., & Rees, W. (2013, March). *Closing the Loop: Reducing Greenhouse Gas Emissions and Creating Green Jobs Through Zero Waste in BC*. Retrieved from Canadian Centre for Policy Alternatives website: http://www.policyalternatives.ca/sites/default/files/uploads/publications/BC%20Office/2013/03/CCPA-BC-Zero-Waste.pdf
- PlasticsEurope. (n.d.). *How plastic is made*. Retrieved from http://www.plasticseurope.org/what-is-plastic/how-plastic-is-made.aspx
- The Green Scientist. (2010, August 31). A guide to safe plastic's use [Web log post]. Retrieved from http://greenscientist.ca/?p=80

REFERENCES

[i] Metro Vancouver. (2011). *Just the Facts: Disposed Waste Only, 2011 Waste Composition Summary Table*. Retrieved from http://www.metrovancouver.org/services/solidwaste/Resources/Documents/QuickFactsOnRegionalWasteDisposal2011.pdf

[ii] City of Vancouver. (2012). *Greenest City 2020 Action Plan*. Retrieved from http://vancouver.ca/files/cov/Greenest-city-action-plan.pdf

[iii] Metro Vancouver. (2010, July). *Integrated Solid Waste and Resource Management: A Solid Waste Management Plan for the Greater Vancouver Regional District and Member Municipalities*. Retried from http://www.metrovancouver.org/about/publications/Publications/ISWRMP.pdf

[iv] TRI Environmental Consulting Inc. (2011, May 11). *Metro Vancouver 2011 Solid Waste Composition Monitoring* (Project no. M53.203). Retrieved from Metro Vancouver website: http://www.metrovancouver.org/about/publications/Publications/2011_Waste_Composition_Report.pdf

[v] Lee, T. (2012, August 21). The Tiffin Project tackles takeout waste with Vancouver restaurants. *Straight.com*. Retrieved from http://www.straight.com/food/tiffin-project-tackles-takeout-waste-vancouver-restaurants

[vi] Small Business BC. (2010). *Market Research Profile 2010: Metro Vancouver Restaurant Profile*. Retrieved from http://www.smallbusinessbc.ca/sbbcfiles/files/Restaurant%20Profile%20-%20Sample%20Page.pdf

[vii] Canadian Council of Ministers of the Environment. (2009, June). *Canada-Wide Action Plan For Extended Producer Responsibility.* Retrieved from CCME Website: http://www.ccme.ca/assets/pdf/epr_cap.pdf

[viii] Metro Vancouver. (2013, October 16). Dr. Michael Braungart-Zero Waste and Cradle to Cradle [Video file]. Retrieved http://www.metrovancouver.org/zwc/presentations/Pages/default.aspx

[ix] Sound Resource Management Group, Inc. (2009, June). *Environmental Life Cycle Assessment of Waste Management Strategies with a Zero Waste Objective: Study of the Solid Waste Management System in Metro Vancouver, British Columbia*. Retrieved from Recycling Council of British Columbia website: http://www.rcbc.ca/files/u7/ement_for_ZeroWaste_Objective_ReportJune2009.pdf

[x] Lee, M., Legg, R., Maxwell, S., & Rees, W. (2013, March). *Closing the Loop: Reducing Greenhouse Gas Emissions and Creating Green Jobs Through Zero Waste in BC*. Retrieved from Canadian Centre for Policy Alternatives website: http://www.policyalternatives.ca/sites/default/files/uploads/publications/BC%20Office/2013/03/CCPA-BC-Zero-Waste.pdf

[xi] Lapointe, R. (2012, Septembre 6). *Bioplastiques biodégradables, compostables et biosourcés pour les emballages alimentaires, distinctions subtiles mais significatives* (Master's thesis). Retrieved from *http://www.usherbrooke.ca/environnement/fileadmin/sites/environnement/documents/Essais2012/Lapointe_R__06-09-2012_.pdf*

[xii] European Bioplastics. (2009, July). *"Oxo-Biodegradable" Plastics*. Retrieved from http://en.european-bioplastics.org/wp-content/uploads/2011/04/pp/Oxo_PositionsPaper.pdf

[xiii] Biodegradable Products Institute, Inc. (2012). *The Myths of Biodegradation*. Retrieved from http://www.bpiworld.org/Default.aspx?pageId=190439

[xiv] Environment Industry Plastics Council (EPIC). (2012). *Position on biodegradability and landfills-1.* Retrieved from http://www.bpiworld.org/Default.aspx?pageId=190439

[xv] Metro Vancouver. (2011). *Ban on disposing food and compostable organics*. Retrieved from http://www.metrovancouver.org/SERVICES/SOLIDWASTE/BUSINESSES/ORGANICSBAN/Pages/default.aspx

[xvi] Willard. B. (2011). *The Sustainability Advantage – About.* Retrieved from http://www.sustainabilityadvantage.com/products/sustainadv.html

[xvii] Ibid. 2011.

[xviii] Ibid. 2011.

[xix] Multi Material BC. (n.d.). *Plan Overview*. Retrieved from http://multimaterialbc.ca/plan-overview

[xx] Aldridge, S., & Miller, L. (2012). *Why Shrink-wrap a cucumber: The Complete Guide to Environmental Packaging*. London: Laurence King Publishers.

[xxi] Solyom, C. (n.d.). Now and forever: The Styrofoam dilemma. *Canada.com*. Retrieved from http://www.canada.com/life/forever+Styrofoam+dilemma/1522634/story.html
[xxii] Clean Water Action. (n.d.). *Phase Out Foam*. Retrieved from http://cleanwateraction.org/ca/rethinkdisposable/phaseoutfoam
[xxiii] No Foam Chicago. (2010). *Cities that have Banned Styrofoam-Food Packaging*. Retrieved from http://nofoamchicago.org/NFC_Citiesbannedlist.pdf
[xxiv] Canadian Plastics Industry Association. (2013). *Plastics 101*. Retrieved from http://www.plastics.ca/articles_merge/plastics101.php
[xxv] PlasticsEurope. (n.d.). *How plastic is made*. Retrieved from http://www.plasticseurope.org/what-is-plastic/how-plastic-is-made.aspx
[xxvi] Integrated Waste Management Board of the State of California. (2004, December). *Use and Disposal of Polystyrene in California: A Report to the California Legislature*. Retrieved from California Department of Resources Recycling and Recovery (CalRecycle) website: http://www.calrecycle.ca.gov/publications/Documents/Plastics%5C43204003.pdf
[xxvii] Aldridge, S., & Miller, L. (2012). *Why Shrink-wrap a cucumber: The Complete Guide to Environmental Packaging*. London: Laurence King Publishers.
[xxviii] Zabaniotou, A., & Kassidi, E. (2003). Life cycle assessment applied to egg packaging made from polystyrene and recycled paper. *Journal of Cleaner Production, 11, 549–559*. http://dx.doi.org/10.1016/S0959-6526(02)00076-8
[xxix] Solyom, C. (n.d.). Now and forever: The Styrofoam dilemma. *Canada.com*. Retrieved from http://www.canada.com/life/forever+Styrofoam+dilemma/1522634/story.html
[xxx] Waste Diversion Ontario. (n.d*.). Densification and Recycling of Post-Consumer Polystyrene (PS #6) Packaging in Ontario Municipalities: Feasibility of Mobile PS Recycling System and Other Processing Opportunities.* Retrieved from Continuous Improvement Fund website: http://cif.wdo.ca/pdf/reports/130/130_report.pdf
[xxxi] Ibid. n.d.
[xxxii] Winsa, P. (2010, April 26). Plastic, glass and paper pile up as recyclers close. *Toronto Star Newspapers*. Retrieved from http://www.thestar.com/news/gta.html
[xxxiii] Waste Diversion Ontario. (n.d.). *Densification and Recycling of Post-Consumer Polystyrene (PS #6) Packaging in Ontario Municipalities: Feasibility of Mobile PS Recycling System and Other Processing Opportunities.* Retrieved from Continuous Improvement Fund website: http://cif.wdo.ca/pdf/reports/130/130_report.pdf
[xxxiv] Canadian Plastics Industry Association. (2012, March 8). *Foam Problem to Opportunity the New Paradigm for Polystyrene Foam Recycling*. Retrieved from http://www.plastics.ca/_files/file.php?fileid=itemHwJeKdVQla&filename=file_BC_webinar_5.3.1.pdf
[xxxv] Integrated Waste Management Board of the State of California. (2004, December). *Use and Disposal of Polystyrene in California: A Report to the California Legislature*. Retrieved from California Department of Resources Recycling and Recovery (CalRecycle) website: http://www.calrecycle.ca.gov/publications/Documents/Plastics%5C43204003.pdf
[xxxvi] Waste Diversion Ontario. (n.d.). *Densification and Recycling of Post-Consumer Polystyrene (PS #6) Packaging in Ontario Municipalities: Feasibility of Mobile PS Recycling System and Other Processing Opportunities.* Retrieved from Continuous Improvement Fund website: http://cif.wdo.ca/pdf/reports/130/130_report.pdf
[xxxvii] Integrated Waste Management Board of the State of California. (2004, December). *Use and Disposal of Polystyrene in California: A Report to the California Legislature*. Retrieved from California Department of Resources Recycling and Recovery (CalRecycle) website: http://www.calrecycle.ca.gov/publications/Documents/Plastics%5C43204003.pdf
[xxxviii] Canadian Plastics Industry Association. (2012, March 8). *Foam Problem to Opportunity the New Paradigm for Polystyrene Foam Recycling*. Retrieved from http://www.plastics.ca/_files/file.php?fileid=itemHwJeKdVQla&filename=file_BC_webinar_5.3.1.pdf
[xxxix] Truefoam Limited. (2012). *About EPS*. Retrieved from http://www.truefoam.com/en/home/abouteps/default.aspx
[xl] Canadian Plastics Industry Association. (2012, March 8). *Foam Problem to Opportunity the New Paradigm for Polystyrene Foam Recycling*. Retrieved from http://www.plastics.ca/_files/file.php?fileid=itemHwJeKdVQla&filename=file_BC_webinar_5.3.1.pdf

[xli] Integrated Waste Management Board of the State of California. (2004, December). *Use and Disposal of Polystyrene in California: A Report to the California Legislature*. Retrieved from California Department of Resources Recycling and Recovery (CalRecycle) website: http://www.calrecycle.ca.gov/publications/Documents/Plastics%5C43204003.pdf

[xlii] Wiliiams R., Ashe, E., & O'Hara, P. D. (2011). Marine mammals and debris in coastal waters of British Columbia, Canada. *Marine Pollution Bulletin*, 62, 1303–1316. Retrieved from http://www.raincoast.org/wp-content/uploads/Williams-etal-2011_marine-debris.pdf

[xliii] Integrated Waste Management Board of the State of California. (2004, December). *Use and Disposal of Polystyrene in California: A Report to the California Legislature*. Retrieved from California Department of Resources Recycling and Recovery (CalRecycle) website: http://www.calrecycle.ca.gov/publications/Documents/Plastics%5C43204003.pdf

[xliv] Ahmad M**.**, & Bajahlan A. S. (2007). Leaching of styrene and other aromatic compounds in drinking water from PS bottles. *Journal of Environmental Sciences*, 19, 421–426. DOI:10.1016/S1001-0742(07)60070-9

[xlv] International Agency for Research on Cancer. (2002). *Some Traditional Herbal Medicines, Some Mycotoxins, Naphthalene and Styrene* [Monograph]. Retrieved from IARC Monographs on the Evaluation of Carcinogenic Ricks to Humans database.

[xlvi] Ahmad M**.**, & Bajahlan A. S. (2007). Leaching of styrene and other aromatic compounds in drinking water from PS bottles. *Journal of Environmental Sciences*, 19, 421–426. DOI:10.1016/S1001-0742(07)60070-9

[xlvii] American Cancer Society, Inc. (2013). *Known and Probable Human Carcinogens Introduction*. Retrieved from http://www.cancer.org/cancer/cancercauses/othercarcinogens/generalinformationaboutcarcinogens/known-and-probable-human-carcinogens

[xlviii] Canadian Plastics Industry Association. (2013). *Plastics 101*. Retrieved from http://www.plastics.ca/articles_merge/plastics101.php

[xlix] PlasticsEurope. (n.d.). *How plastic is made*. Retrieved from http://www.plasticseurope.org/what-is-plastic/how-plastic-is-made.aspx

[l] Aldridge, S., & Miller, L. (2012). *Why Shrink-wrap a cucumber: The Complete Guide to Environmental Packaging*. London: Laurence King Publishers.

[li] Canadian Plastics Industry Association. (2013). *Plastics 101*. Retrieved from http://www.plastics.ca/articles_merge/plastics101.php

[lii] PlasticsEurope. (n.d.). *How plastic is made*. Retrieved from http://www.plasticseurope.org/what-is-plastic/how-plastic-is-made.aspx

[liii] Ibid. n.d.

[liv] British Plastics Federation. (n.d.). *Plastic Processes*. Retrieved from http://www.bpf.co.uk/Plastipedia/Processes/Default.aspx

[lv] Canadian Plastics Industry Association. (2013). *Plastics 101*. Retrieved from http://www.plastics.ca/articles_merge/plastics101.php

[lvi] British Plastics Federation. (n.d.). *Plastic Processes*. Retrieved from http://www.bpf.co.uk/Plastipedia/Processes/Default.aspx

[lvii] PlasticsEurope. (n.d.). *How plastic is made*. Retrieved from http://www.plasticseurope.org/what-is-plastic/how-plastic-is-made.aspx

[lviii] Canadian Plastics Industry Association. (2013). *Plastics 101*. Retrieved from http://www.plastics.ca/articles_merge/plastics101.php

[lix] Aldridge, S., & Miller, L. (2012). *Why Shrink-wrap a cucumber: The Complete Guide to Environmental Packaging*. London: Laurence King Publishers.

[lx] US Energy Information Administration. (n.d.). *Frequently Asked Questions: How much oil is used to make plastic?* Retrieved from http://www.eia.gov/tools/faqs/faq.cfm?id=34&t=6

[lxi] United States Environmental Protection Agency. (2013). *Waste Reduction Model (WARM)*. Retrieved from http://epa.gov/epawaste/conserve/tools/warm/index.html

[lxii] United States Environmental Protection Agency. (2013). *Calculations and References*. Retrieved from http://www.epa.gov/cleanenergy/energy-resources/refs.html

[lxiii] Waste and resources Action program (WRAP). (2013). *Benefits to Business*. Retrieved from http://www.wrap.org.uk/content/benefits-business

[lxiv] PlasticsEurope. (n.d.). *How plastic is made*. Retrieved from http://www.plasticseurope.org/what-is-plastic/how-plastic-is-made.aspx
[lxv] Aldridge, S., & Miller, L. (2012). *Why Shrink-wrap a cucumber: The Complete Guide to Environmental Packaging*. London: Laurence King Publishers.
[lxvi] British Plastics Federation. (n.d.). *Plastic Processes*. Retrieved from http://www.bpf.co.uk/Plastipedia/Processes/Default.aspx
[lxvii] Aldridge, S., & Miller, L. (2012). *Why Shrink-wrap a cucumber: The Complete Guide to Environmental Packaging*. London: Laurence King Publishers.
[lxviii]United States Environmental Protection Agency. (2013). *Waste Reduction Model (WARM)*. Retrieved from http://epa.gov/epawaste/conserve/tools/warm/index.html
[lxix] Ibid. 2013.
[lxx] Franklin Associates. (2011, January 19). *Revised Final Report: Life Cycle Inventory of 100% Postconsumer HDPE and PET Recycled Resin from Postconsumer Containers and Packaging*. Retrieved from The Plastics Division of the American Chemistry Council website: http://plastics.americanchemistry.com/Education-Resources/Publications/Life-Cycle-Inventory-of-Postconsumer-HDPE-and-PET-Recycled-Resin.pdf
[lxxi] Aldridge, S., & Miller, L. (2012). *Why Shrink-wrap a cucumber: The Complete Guide to Environmental Packaging*. London: Laurence King Publishers.
[lxxii] Sustainable Packaging Coalition, a project of GreenBlue. (2009). *Closing the Loop: A Guide to Packaging Material Flows and Terminology*. Retrieved from Wisconsin State Legislature Legislative Council website: http://legis.wisconsin.gov/lc/committees/study/2010/SUP/files/ClosingtheLoopGreenBlue.pdf
[lxxiii] Marsh, K., & Bugusu, B. (2007). Food Packaging-Roles, Materials, and Environmental Issues. *Journal of Food Science*, 72, R39-R55. Retrieved from http://ift.org/knowledge-center/read-ift-publications/science-reports/scientific-status-summaries/~/media/Knowledge%20Center/Science%20Reports/Scientific%20Status%20Summaries/FoodPackagingEnviron_0407.pdf
[lxxiv] Sustainable Packaging Coalition, a project of GreenBlue. (2009). *Closing the Loop: A Guide to Packaging Material Flows and Terminology*. Retrieved from Wisconsin State Legislature Legislative Council website: http://legis.wisconsin.gov/lc/committees/study/2010/SUP/files/ClosingtheLoopGreenBlue.pdf
[lxxv] New Hampshire Department of Environmental Services. (2008). *Time it takes for garbage to decompose in the environment*. Retrieved from http://des.nh.gov/organization/divisions/water/wmb/coastal/trash/documents/marine_debris.pdf
[lxxvi] Barlaz, M. A., Schaefer, D. M., & Ham, R. K. (1989). Bacterial Population Development and Chemical Characteristics of Refuse Decomposition in a Simulated Sanitary Landfill. *Applied and Environmental Microbiology*, 55(1), 56-65. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC184054/pdf/aem00094-0075.pdf
[lxxvii] Laist, D. W. (1987). Overview of the Biological Effects of Lost and Discarded Plastic Debris in the Marine Environment. *Marine Pollution Bulletin*, 18(6), 319-326. http://dx.doi.org/10.1016/S0025-326X(87)80019-X
[lxxviii] British Plastics Federation. (n.d.). *Plastic Additives*. Retrieved from http://www.bpf.co.uk/plastipedia/additives/default.aspx
[lxxix] Barlaz, M. A., Schaefer, D. M., & Ham, R. K. (1989). Bacterial Population Development and Chemical Characteristics of Refuse Decomposition in a Simulated Sanitary Landfill. *Applied and Environmental Microbiology*, 55(1), 56-65. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC184054/pdf/aem00094-0075.pdf
[lxxx] Kijchavengkul, T., & Auras, R. (2008). Compostability of polymers. *Polymer International*, 57(6), 793–804. http://dx.doi.org/10.1002/pi.2420
[lxxxi] The Ocean Conservancy. (2005). *Pocket Guide to Marine Debris*. Retrieved from Coordinating Body on the Seas of East Asia (COBSEA) website: http://www.cobsea.org/cleanupeas/docs/ICC_PocketGuide_EN.pdf
[lxxxii] Moore, C. J., Moore, S. L., Leecaster, M. K., & Weisberg, S. B. (2001). A Comparison of Plastic and Plankton in the North Pacific Central Gyre. *Marine Pollution Bulletin*, 42(12), 1297-1300. Retrieved from http://5gyres.org/media/Moore_2001_plastic_in_North_Pacific_Gyre.pdf
[lxxxiii] Jordan, C. (2009). *The Great Pacific Garbage Patch* [Photograph]. Retrieved from http://www.treehugger.com/clean-technology/chris-jordan-takes-shots-at-the-trash-patch.html

[lxxxiv] Laist, D. W. (1987). Overview of the Biological Effects of Lost and Discarded Plastic Debris in the Marine Environment. *Marine Pollution Bulletin*, 18(6), 319-326. Retrieved from http://www.sciencedirect.com/science/article/pii/S0025326X8780019X
[lxxxv] Boerger, C. M., Lattin, G. L., Moore, S. L., & Moore, C. J. (2010). Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre. *Marine Pollution Bulletin*, 60, 2275-2278. Retrieved from http://www.algalita.org/uploads/PlasticingestionbyplanktivorousfishesintheNorthPacificCentralGyre-1.pdf
[lxxxvi] Ibid. 2010.
[lxxxvii] United Nations Environment Programme. (2011). *Plastic Debris in the Ocean*. Retrieved from http://www.unep.org/yearbook/2011/pdfs/plastic_debris_in_the_ocean.pdf
[lxxxviii] Schuyler, Q., Hardesty, B. D., Wilcox, C., & Townsend, K. (2013). Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles. *Conservation Biology*, 1-11. Retrieved from http://onlinelibrary.wiley.com/store/10.1111/cobi.12126/asset/cobi12126.pdf?v=1&t=ho50mkqh&s=fab8478c8a89a0f8b045c82be0aaff0ddd2baa19
[lxxxix] Wiliiams R., Ashe, E., & O'Hara, P. D. (2011). Marine mammals and debris in coastal waters of British Columbia, Canada. *Marine Pollution Bulletin*, 62, 1303–1316. Retrieved from http://www.raincoast.org/wp-content/uploads/Williams-etal-2011_marine-debris.pdf
[xc] Avery-Gomm, S., O'Hara, P. D., Kleine, L., Bowes, V., Wilson, L. K., & Barry, K. L. (2012). Northern fulmars as biological monitors of trends of plastic pollution in the eastern North Pacific. *Marine Pollution Bulletin*, 64, 1776-1781. http://dx.doi.org/10.1016/j.marpolbul.2012.04.017
[xci] Derraik, J. G. B. (2002). The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin*, 44, 842-852. Retrieved from http://www.caseinlet.org/uploads/Moore--Derraik_1_.pdf
[xcii] Mato, Y., Isobe, T., Takada, H., Kanehiro, H., Ohtake, C., & Kaminuma, T. (2001). Plastic Resin Pellets as a Transport Medium for Toxic Chemicals in the Marine Environment. *Environmental Science & Technology*, 35, 318-324. DOI:10.1021/es0010498
[xciii] Derraik, J. G. B. (2002). The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin*, 44, 842-852. Retrieved from http://www.caseinlet.org/uploads/Moore--Derraik_1_.pdf
[xciv] UC RUSAL. (n.d.). *Al Facts: How Is It Produced?* Retrieved from http://www.aluminiumleader.com/en/facts/extraction/
[xcv] Rio Tinto. (2013). *Making aluminum*. Retrieved from http://www.riotintoalcan.com/eng/whatweproduce/360_making_aluminium.asp
[xcvi] Sustainable Packaging Coalition, a project of GreenBlue. (2009). *Closing the Loop: A Guide to Packaging Material Flows and Terminology*. Retrieved from Wisconsin State Legislature Legislative Council website: http://legis.wisconsin.gov/lc/committees/study/2010/SUP/files/ClosingtheLoopGreenBlue.pdf
[xcvii] Bergsdal, H., Strømman, A. H., & Hertwich, E. G. (2004). *The Aluminium Industry: Environment, Technology and Production.* Retrieved from Norwegian University of Science and Technology (NTNU) website: http://www.ntnu.no/c/document_library/get_file?uuid=90a62bb5-9451-476e-abbf-076a6b42604d&groupId=10370
[xcviii] See Appendix 2
[xcix] Bergsdal, H., Strømman, A. H., & Hertwich, E. G. (2004). *The Aluminium Industry: Environment, Technology and Production.* Retrieved from Norwegian University of Science and Technology (NTNU) website: http://www.ntnu.no/c/document_library/get_file?uuid=90a62bb5-9451-476e-abbf-076a6b42604d&groupId=10370
[c] Ibid. 2004.
[ci] Zabaniotou, A. & Kassidi, E. (2003). Life cycle assessment applied to egg packaging made from polystyrene and recycled paper. *Journal of Cleaner Production*, 11, 549-559. Retrieved from http://www.tud.ttu.ee/material/piirimae/LCA/Case%20studies/LCA%20egg%20packaging.pdf
[cii] Ibid. 2003.
[ciii] Ibid. 2003.
[civ] Marsh, K., & Bugusu, B. (2007). Food Packaging-Roles, Materials, and Environmental Issues. *Journal of Food Science*, 72, R39-R55. Retrieved from http://ift.org/knowledge-center/read-ift-publications/science-reports/scientific-status-

summaries/~/media/Knowledge%20Center/Science%20Reports/Scientific%20Status%20Summaries/FoodPackagingEnviron_0407.pdf
[cv] Ibid. 2007.
[cvi] Ibid. 2007.
[cvii] Martin, S. (2011, September 10). *Paper Chase*. Retrieved from Ecology Communications Group, Inc.: http://www.ecology.com/2011/09/10/paper-chase/
[cviii] Ibid. 2011.
[cix] Zabaniotou, A. & Kassidi, E. (2003). Life cycle assessment applied to egg packaging made from polystyrene and recycled paper. *Journal of Cleaner Production*, 11, 549-559. Retrieved from http://www.tud.ttu.ee/material/piirimae/LCA/Case%20studies/LCA%20egg%20packaging.pdf
[cx] Sustainable Foodservice Consulting. (2013). *Sustainable, Disposable Foodservice Products.* Retrieved from Sustainable Foodservice.com: http://www.sustainablefoodservice.com/cat/disposables.htm
[cxi] Ibid. 2013.
[cxii] Ibid. 2013.
[cxiii] Ibid. 2003.
[cxiv] Ibid. 2013.
[cxv] Ibid. 2013.
[cxvi] Marsh, K., & Bugusu, B. (2007). Food Packaging-Roles, Materials, and Environmental Issues. *Journal of Food Science*, 72, R39-R55. Retrieved from http://ift.org/knowledge-center/read-ift-publications/science-reports/scientific-status-summaries/~/media/Knowledge%20Center/Science%20Reports/Scientific%20Status%20Summaries/FoodPackagingEnviron_0407.pdf
[cxvii] Ibid. 2007.
[cxviii] Ibid. 2007.
[cxix] Madival, S., Auras, R., Singh, S. P., & Narayan, R. (2009). Assessment of the environmental profile of PLA, PET and PS clamshell containers using LCA methodology. *Journal of Cleaner Production*, 17, 1183-1194. http://dx.doi.org/10.1016/j.jclepro.2009.03.015
[cxx] Marsh, K., & Bugusu, B. (2007). Food Packaging-Roles, Materials, and Environmental Issues. *Journal of Food Science*, 72, R39-R55. Retrieved from http://ift.org/knowledge-center/read-ift-publications/science-reports/scientific-status-summaries/~/media/Knowledge%20Center/Science%20Reports/Scientific%20Status%20Summaries/FoodPackagingEnviron_0407.pdf
[cxxi] PrimeLink Solutions, LLC. (2012). *Eco-Friendly Compostable Food Containers Rapidly Replacing Styrofoam Clamshells Nationwide*. Retrieved from PrimeWare: http://www.primelinksolution.com/sustainable-compostable/bagasse-vs-styrofoam
[cxxii] Ibid. 2012.
[cxxiii] Ibid. 2012.
[cxxiv] PrimeLink Solutions, LLC. (2009). *What is Bagasse?* Retrieved from PrimeWare: http://www.primelinksolution.com/sustainable-products-information/press-releases/118-what-is-bagasse
[cxxv] Marsh, K., & Bugusu, B. (2007). Food Packaging-Roles, Materials, and Environmental Issues. *Journal of Food Science*, 72, R39-R55. Retrieved from http://ift.org/knowledge-center/read-ift-publications/science-reports/scientific-status-summaries/~/media/Knowledge%20Center/Science%20Reports/Scientific%20Status%20Summaries/FoodPackagingEnviron_0407.pdf
[cxxvi] Ibid. 2007.
[cxxvii] Bastioli, C. (2001). Global Status of the Production of Biobased Packaging Materials. *Die Stärke*, 53, 351-355. http://dx.doi.org/10.1002/1521-379X(200108)53:8<351::AID-STAR351>3.0.CO;2-R
[cxxviii] Ibid. 2001.
[cxxix] Ibid. 2001.
[cxxx] Ibid. 2001.
[cxxxi] Ibid. 2001.

[cxxxii] Royte, E. (2006, August). Corn Plastic to the Rescue. *Smithsonian magazine*. Retrieved from http://www.smithsonianmag.com/science-nature/plastic.html?c=y&page=4
[cxxxiii] Sustainable Foodservice Consulting. (2013). *Sustainable, Disposable Foodservice Products.* Retrieved from Sustainable Foodservice.com: http://www.sustainablefoodservice.com/cat/disposables.htm
[cxxxiv] Royte, E. (2006, August). Corn Plastic to the Rescue. *Smithsonian magazine*. Retrieved from http://www.smithsonianmag.com/science-nature/plastic.html?c=y&page=4
[cxxxv] Ibid. 2006.
[cxxxvi] Natural Greenway. (2012). *Natural bagasse*. Retrieved from Naturalgreenway.com: http://www.naturalgreenway.com/en/products/natural-bagasse.html
[cxxxvii] Viv Biz Club. (n.d.) *Application of Bagasse*. Retrieved from http://vivbizclub.com/2010/02/02/bagasse/
[cxxxviii] Ibid. n.d.
[cxxxix] Ibid. n.d.
[cxl] Ibid. n.d.
[cxli] Ibid. n.d.
[cxlii] PrimeLink Solutions, LLC. (2012). *Eco-Friendly Compostable Food Containers Rapidly Replacing Styrofoam Clamshells Nationwide*. Retrieved from PrimeWare: http://www.primelinksolution.com/sustainable-compostable/bagasse-vs-styrofoam
[cxliii] Ibid. 2012.
[cxliv] Ibid. 2012.
[cxlv] Ibid. 2012.
[cxlvi] PrimeLink Solutions, LLC. (2009). *What is Bagasse?* Retrieved from PrimeWare: http://www.primelinksolution.com/sustainable-products-information/press-releases/118-what-is-bagasse
[cxlvii] Franklin Associates. (2011, February 4). *Life cycle inventory of foam polystyrene, Paper-based, and PLA foodservice products*. Retrieved from The Plastic Foodservice Packaging Group, part of American Chemistry Council, Inc. website: http://plasticfoodservicefacts.com/Life-Cycle-Inventory-Foodservice-Products
[cxlviii] Madival, S., Auras, R., Singh, S. P., & Narayan, R. (2009). Assessment of the environmental profile of PLA, PET and PS clamshell containers using LCA methodology. *Journal of Cleaner Production*, 17, 1183-1194. http://dx.doi.org/10.1016/j.jclepro.2009.03.015
[cxlix] Royte, E. (2006, August). Corn Plastic to the Rescue. *Smithsonian magazine*. Retrieved from http://www.smithsonianmag.com/science-nature/plastic.html?c=y&page=4
[cl] Sustainable Foodservice Consulting. (2013). *Sustainable, Disposable Foodservice Products.* Retrieved from Sustainable Foodservice.com: http://www.sustainablefoodservice.com/cat/disposables.htm
[cli] Royte, E. (2006, August). Corn Plastic to the Rescue. *Smithsonian magazine*. Retrieved from http://www.smithsonianmag.com/science-nature/plastic.html?c=y&page=4
[clii] Ibid. 2006.
[cliii] Sustainable Foodservice Consulting. (2013). *Sustainable, Disposable Foodservice Products.* Retrieved from Sustainable Foodservice.com: http://www.sustainablefoodservice.com/cat/disposables.htm
[cliv] Marsh, K., & Bugusu, B. (2007). Food Packaging-Roles, Materials, and Environmental Issues. *Journal of Food Science*, 72, R39-R55. Retrieved from http://ift.org/knowledge-center/read-ift-publications/science-reports/scientific-status-summaries/~/media/Knowledge%20Center/Science%20Reports/Scientific%20Status%20Summaries/FoodPackagingEnviron_0407.pdf
[clv] Ibid. 2007.
[clvi] City of Vancouver. (2013). *Green Bin Program: Toward zero waste*. Retrieved from http://vancouver.ca/green-vancouver/food-scraps-program.aspx
[clvii] Metro Vancouver. (2011). *Ban on disposing food and compostable organics*. Retrieved from http://www.metrovancouver.org/SERVICES/SOLIDWASTE/BUSINESSES/ORGANICSBAN/Pages/default.aspx
[clviii] The Nature Conservancy. (2011, November 8). How Green Is Compostable Packaging? *Care2.com.* Retrieved from http://www.care2.com/greenliving/how-green-is-compostable-packaging.html?page=1
[clix] Vartan, S. (2010, August 8). Compostable Packaging Test: Whole Foods Deli Containers. *Inhabitat.com*. Retrieved from http://inhabitat.com/compostable-packaging-test-whole-foods-deli-containers/
[clx] World Centric. (2013). *Frequently Asked Questions*. Retrieved from http://worldcentric.org/faq.html

[clxi] Ibid. 2013.
[clxii] Ibid. 2013.
[clxiii] Ibid. 2013.
[clxiv] The Tiffin Project. (n.d.). *The Tiffin Project*. Retrieved from http://thetiffinproject.com/
[clxv] Go Box. (n.d.). *Doing Away with Throw Away!* Retrieved from http://www.goboxpdx.com/
[clxvi] Bizeebox. (2013). *Take the Waste out of Takeout*. Retrieved from http://bizeebox.com/
[clxvii] Simon Fraser University. (n.d.). *Container Exchange Program*. Retrieved from http://www.sfu.ca/sustainability/initiatives/waste/container-exchange-program.html