CHARACTERIZING ICI&I TEXTILE WASTE IN HALIFAX, NOVA SCOTIA

by

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

at

Dalhousie University
Halifax, Nova Scotia
April, 2018

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Note: *All terms defined in the glossary (p.45) are italicized the first time they appear in the document.*

Acknowledgments

Abstract

Textile waste is growing problem around the world. Relative to other recyclable materials, textile waste management remains largely unexplored among industrialized countries, particularly for textile waste produced by institutions, businesses, and industrial operations (ICI). Textiles account for 12% of the municipal solid waste stream in Nova Scotia with half originating from ICI sources. Thus, there is a need to understand the sources, types, and disposal options for ICI textiles in Nova Scotia. This study gathered baseline information on existent waste management practices, discard rates, as well as benefits of and barriers to textile diversion within Nova Scotia's ICI sector. This was accomplished by interviewing representatives from organizations who produce textile waste in Nova Scotia, with a focus on those within Halifax. To provide context, interviews were also sought with waste management stakeholders and with other professionals with related expertise. A jurisdictional review of diversion initiatives and markets for ICI textile discards was also carried out for North America and Europe. The results highlighted various diversion efforts among the ICI organizations, particularly for reuse grade material. This study also found an absence of industry, municipal, and provincial involvement in organizational diversion efforts. Finally, management initiatives and markets were found to be lacking for recycle grade textiles produced by the ICI organizations. This pilot study identified opportunities to increase textile waste diversion within Halifax's ICI sector and Nova Scotia as a whole. With further investigation of management and policy implications, several practical solutions could arise which would have immediate benefits in significantly reducing the amount of textiles going to landfill in Nova Scotia.

1. Introduction

1.1 The Problem

Consumption and disposal of textiles is a growing problem in Canada and around the world. In Nova Scotia, textiles are not banned from disposal in landfill (Solid Waste Resource Regulations [SWRR], 1995, s. 102). Based on the most recent waste audit results, textile waste accounts for 12% of Nova Scotia's municipal solid waste stream, which corresponds to 30,000 tonnes per year or 32kg per person (Divert Nova Scotia [Divert NS], 2011; 2012). The *Industrial, Commercial, and Institutional (ICI)* sector accounts for approximately half this waste. In this context, textile waste includes clothing, footwear, household linens, and other items woven from fabric but excludes mattresses, carpets, furniture and other bulky items (Divert NS, 2012).

Nova Scotia is considered a Canadian pioneer in solid waste diversion with a disposal rate at almost half the national average (Province of Nova Scotia [PNS], 2016). However, disposal rates have plateaued in recent years and we have yet to achieve our 2015 goal of a 300kg per capita disposal rate as set out by the *Environmental Goals and Sustainable Prosperity Act* (2007) (EGSPA, 2007, c. 7, s. 1; PNS, 2016). In an effort to lower disposal rates, the province has set out material-specific strategies to target items that continue to dominate the waste stream (personal communication, R. Kenney, September 21, 2017). One important step toward this goal is likely to be understanding the sources, types, and destinations of ICI textiles entering the waste stream.

There exists no formal province-wide strategy for managing textile waste among Canadian jurisdictions (Gioux, 2014). The Association for Textile Recycling (AFTeR), a collaboration of six charitable organizations, manage collection systems and reuse programs for used textiles in

Nova Scotia (AFTeR, 2014). Together, they divert approximately 19% of the province's textile waste. These programs remain voluntary and are primarily geared towards capturing textile waste from the residential sector. It is unknown how much ICI textile waste is captured by AFTeR members. ICI establishments can generate relatively larger volumes of textile waste compared to more distributed waste from the residential sector. In addition, many ICI organizations also produce *pre-consumer textile* waste, often in the form of scraps, which, compared to reusable textile discards, require reprocessing and thus are not as easily divertible. Overall, it is estimated that 15,000 tonnes of textiles are disposed by the ICI sector each year (Divert NS, 2011; 2012).

This study examined ICI textile waste generators in Nova Scotia, with a focus on the Halifax area. Data was gathered on ICI textile waste quantities, types, management practices, as well as benefits and barriers to diversion. Information was also assembled for other jurisdictions, organizations, and textile recyclers leading the way in ICI textile diversion.

1.2 Background

The demand for clothing, footwear, and other textile goods has manifested into a global industry with far-reaching environmental, economic, and social impacts (Bolsröm & Micheletti, 2016). When textile manufacturing shifted from industrialized to low-wage countries in the 1950's, textile consumption and disposal rates grew as the price of textiles plummeted and consumers became increasingly separated from the production process. Consequently, the outsourcing of textile production and the rise of fast fashion has placed the financial, social, and environmental burden of textile production on farmers, factory workers, and ecosystems at either end of the commodity chain (Bolsröm & Micheletti, 2016). On the demand side, the

abundant availability of cheap clothing and other textile goods has incited a disposal culture and the primary disposal method for textiles is now in landfills i.e. disposed in the garbage waste stream (e.g. Kirboe, Kjr, Kogg, Tojo, & Aalto, 2012; Council for Textile Recycling, 2018). Similar to organic waste, textiles release large amounts of methane as they degrade in landfills. Synthetic textile dyes also pose a problem for landfill operators as they can contaminate soils and groundwater, equating to a relatively high waste management costs for textiles (Turner, Williams, & Kemp, 2015; Weber, Lynes, & Young, 2017). Needless to say, the global textile economy is a complex interwoven system that requires serious reevaluating in light of rising health and sustainability concerns. Efforts at both ends of the commodity chain should and are now being taken to reduce the impacts of textiles at the global, regional, and local scale.

There is still much work to be done in the area of textile diversion. While data lacks at the global level, the Council for Textile Recycling (CRT) reports that Americans dispose of 32kg of textiles per person per year, with 85% of of all used textiles going to landfill (CRT, 2018). Increasing the diversion of any material requires collaboration between consumers, the private sector, and governments alike (Bolström & Mcheletti, 2016; Dahlbo et al., 2017).

Among North American jurisdictions, Nova Scotia is considered a pioneer in waste diversion (Wagner, 2007). As part of a provincial strategy to lower disposal rates, Nova Scotia began banning recyclable materials from landfills in 1995 (*SWRR*, 1995, s 102). By 2000, Nova Scotia was the only province to achieve the national goal set out by the Canadian Council of Minister of Environment (CCME), diverting 50% of provincial waste from the 1989 baseline figure (Wagner & Arnold, 2006). However, Nova Scotia's disposal rate has stalled in recent years at approximately 400kg per person (PNS, 2016). This has prompted government officials, Divert

NS, and other stakeholders to begin strategizing on how to target materials that account for large proportions of the waste stream (NSE, 2015; personal communication, R. Kenney, NSE, September 21, 2017).

As previously mentioned, it is difficult to assess AFTeR's impact on diverting ICI textile waste. Of the 7,000 tonnes of textiles AFTeR collects each year across Nova Scotia, there is no mechanism for distinguishing between residential and ICI textile waste. While waste audits do distinguish between residential and ICI waste, provincial waste audit data is measured at the landfill level and thus cannot speak to the origins of the 15,000 tonnes of textiles disposed by the ICI sector each year. Understanding the distribution of such waste is critical for devising future waste management strategies and lowering provincial disposal rates.

1.3 Knowledge Gaps

Data on textile waste is lacking at the national level in Canada, where the 701kg/person disposal rate has not yet been broken down into waste subcategories (Statistics Canada, 2014). Textile diversion is a relatively new endeavor for developed economies compared to other recyclable materials. Current research highlights efforts among the Nordic countries (e.g. Kirboe et al., 2012; Paras & Pal, 2017), San Francisco (Ulasewicz & Baugh, 2013), British Columbia (Metro Vancouver 2017; Recycling Council of British Columbia, 2017), and Markham, Ontario (Markham, 2016). However, the body of research has primarily focused on residential textile diversion.

As it stands, little research has yet been conducted on non-residential textile waste diversion, particularly in Nova Scotia where current data is mostly in the form of estimates by governmental and non-governmental agencies (e.g. AFTeR, 2014; Divert NS, 2011; 2012). AFTeR

is also not yet a resource for ICI textile data. Another waste audit will be released in 2018; however, provincial audits do not sample beyond the landfill level. Thus, there is need to explore the issue of ICI textile waste within Nova Scotia at a sub-regional scale.

1.4 Approach and Objectives

This study sought baseline information on ICI textile waste, including existent management practices, estimates of discard rates (turnover rates), as well as the benefits of and barriers to textile waste diversion among ICI organizations. Data was gathered by interviewing representatives from organizations who produce textile waste in Nova Scotia. To narrow the scope, this study focused on generators in the Halifax area. To provide context, interviews were also sought with waste management stakeholders and other professionals in related fields. A jurisdictional review was also carried out to identify any exemplary businesses and jurisdictions with regards to their ICI textile waste diversion. The study was guided by the following research questions:

1. Who are the generators of ICI textile waste in Nova Scotia?

2. What management practices are in place among ICI textile waste generators and which are most commonly employed?

3. What are the challenges and barriers ICI organizations face in terms of managing their textile waste?

4. What are the incentives and benefits to diverting ICI textiles waste?

5. What initiatives and emergent markets exist in other jurisdictions to divert ICI textile waste?

2. Literature Review

This literature review will provide a general overview of scientific research on the textile industry, focusing on environmental impacts and the sustainability of the textile supply chain. Textile consumption and disposal will be explored followed by current research on private and public diversion efforts. A snapshot of waste management and textile diversion efforts will be provided for Nova Scotia, Canada. Finally, significant research gaps in the literature will be identified. The central focus of this literature review is to present the sustainability challenge of the textile supply chain in terms of accounting for textile waste in all its forms. It serves to show the limited nature of existing research on textile waste management and to justify why research on textile waste diversion among Nova Scotian businesses and institutions is deserving of attention in particular.

2.1 The Global Textile Industry

The global textile economy has proven to be a difficult area of study. Its supply chain has become increasingly fragmented since textile production was outsourced to lower-wage countries in the late 1950s, inciting global competition, low market prices, and a myriad of human rights issues (Gereffi, 1999). Today, the industry is described as highly risky and volatile in terms of product turnover, market prices, technological developments, and shifting political climates (Bruce, Daly, & Towers, 2004; Eurles Hermes, 2017). The industry lacks regulation; there are few mechanisms ensuring due diligence along the supply chain thus actors cannot be held accountable. More and better research is needed to identify the individual and collective responsibilities of the stakeholders involved (Boltröm & Michelitti, 2016; Baurraud de Lagerie,

2016). As it stands, the lack of transparency along the textile supply chain complicates scientific research and stifles attempts to effectuate systematic change within the industry.

The textile industry is one of the most polluting industries in the world; negative externalities proliferate throughout the supply chain (Shishoo, 2012). It is the scientific consensus that the production of textile goods is highly impactful on terrestrial, aquatic, and atmospheric environments (e.g. Bhadauria, Rajput, & Pandey, 2017; Dadi et al., 2017; Sharma & Ledwani, 2017; Srinivas & Singh, 2017). Textile fibers are most commonly sourced from genetically modified cotton, which requires extensive energy, land, water, and pesticide inputs (Chequer et al., 2013; Pensupa et al., 2017; Youa, 2009). The synthetic dyes and chemicals used in the textile manufacturing process pose a serious risk to human health and the environment alike, as do the cocktails of agricultural pesticides used in cotton fields (Chequer et al., 2013). To compound the problem, effluent from textile factories is often released into nearby waterways, which, beyond causing eco-toxic impacts, introduces endocrine-disrupting chemicals into the environment that can interfere with natural hormonal processes in humans and wildlife (Croce et al., 2017; Lee, Peart, Gris, & Chan, 2002). Similar to plastics, synthetic fibers, which now account for 63% of all fibers (Lezing, 2016), require petroleum, which makes the resulting material non-biodegradable and the industry dependent on a non-renewable resource (Chen & Burns, 2006). However, natural fibers have been found to be just as or even more impactful as synthetic fibers on a LCA basis, given how resource-intensive global cotton production has become (e.g. Shen, Worell, & Patel, 2010; Van der Velden, Patel, & Vogtländer, 2014). Microfiber pollution from textile wastewater knows no boundaries; fibers are now found in even remote marine environments and synthetic chemicals in the tissues of marine organisms,

where they can accumulate up the food chain and contaminate human protein sources (Browne et. al, 2011; Mathalon & Hill, 2014). All in all, increasing textile production inevitably means increasing water pollution, greenhouse gas emissions, and biodiversity loss – issues that span multiple jurisdictions and generations.

2.1.1 Supply Chain Sustainability

The sustainability of the global textile industry has been called into question by the scientific community in light of increasing environmental concerns of the 21st century. The body of research on the sustainability of the textile supply chain derives its framework from businesses management theories that first emerged in the 1990s. Elkington (1998) first proposed the the Triple Bottom Line (TBL) approach to business management. The theory emphasizes the social, economic, and environmental pillars of the supply chain. Carter and Rogers (2008) build on the TBL approach and developed the theory of Sustainable Supply Chain Management (SSCM). Before that, previous studies had been highly conceptual in nature, defining sustainable development as per the Brundtland definition of sustainability (Seuring & Müller, 2008). Several studies have emphasized the need to consider the social implications of SSCM above the economic and environmental (e.g. Köksal, Strähle, Müller, & Freise, 2017; Barraud de Lagerie, 2016; Zorzini, Hendry, Huq, & Stevenson, 2015), arguing that the textile industry, by it's very nature, predisposes itself to corruption and social injustices that are too often overlooked in scientific literature. Others have identified the need to consider the TBL dimensions as interdependent issues instead of as piecemeal concepts (Seuring & Müller, 2008; Gimenez & Tachizawa, 2012; Walker & Jones, 2012). In any case, the scientific consensus is that more research is needed to advance SSCM in its entirety within the textile industry (Barraud de

Lagerie, 2016; Bolström et al., 2015; Köksal et al., 2017). The body of research investigating the sustainability issues of the textile industry has grown rapidly within the last decade and has served to identify industry shortcomings.

The theoretical framework of SSCM grew in conjunction with increasing environmental and social awareness among both industry practitioners and consumers. According to a literature review by Yang, Song, and Tong (2017), there has been a recent surge in sustainable retailing (e.g. 2014; Goworek et al., 2012; Shen, 2014), green/eco-labeling (e.g. Bly et al., 2015; Lee et al., 2012), second-hand retailing (e.g. Beh at al., 2016; Delai & Takahashi, 2013; Kumar, 2014; Wilson 2015) and reverse logistics/supplier buyback schemes (e.g. Shen & Li, 2015; Shen, Choi, & Lo, 2015). Study methods include reviewing corporate sustainability reports, studying corporate codes of conduct, and conducting sustainability audits (Searcy, 2012; Yong, Song, Tong, 2017). An analysis of corporate reports by Turker & Altuntas (2014) revealed that SSCM is a priority among EU firms and that there was a particular emphasis on supplier management, particularly among firms sourcing from developing countries. Indeed, increasing the sustainability of the textile supply chain has become a key priority within the textile industry.

However, the practical application of SSCM has limitations given the deregulated nature of the industry and that sustainability initiatives remain voluntary. Egels-Zandén and Lindholm, (2015) quantified the limitations of using codes of conduct and performance audits to effect change in the supply chain. Eco-certification has also been called into question as having fundamental limitations (Boström and Karlsson 2013; De Brito, Carbone, & Blanquart, 2008) Turker & Altuntas (2014) concluded that monitoring and compliance enforcement are vital for effective SSCM, which is difficult in a system where policy makers cannot effectively regulate.

As it stands, the success of SSCM applications requires increased effort on the part of governments, industry practitioners, and consumers alike.

Circular Economy (CE) is a broader approach to supply chain sustainability that has yet to take root within the textile industry at any large scale. CE has been dubbed as essentially contested concept in that previous research and application has been highly diverse and fragmented (Korhonen, Nuur, Feldmann, & Birkie, 2018). Fundamentally, CE aims to minimize the amount of virgin material input into a system by following a cradle-to-cradle approach to sustainability (Lieder & Rashid, 2016). This includes designing/purchasing goods for durability, reparability, and recyclability. No matter the definition, CE is only begging to gain traction within the textile industry and scientific community – more theory development and larger-scale applications are called for (Bartle, 2011; Korhonen, Nuur, Feldmann, & Birkie; Lieder & Rashid, 2016).

2.1.2 Textile Consumption and Disposal

Naturally, consumer behavior is a key driver of rising consumption rates. Global textile fiber production quadrupled from 24 million tonnes in 1975 to 95 million in 2016 and is predicted to surpass 100 million tonnes by 2020, averaging a 3-4% annual growth rate (Lezing, 2016). Many studies have highlighted the influence of consumer values on the fashion industry (e.g. Bruce & Daly 2006; Ciasullo, Maione, Torre, & Troisi, 2017; Kukar-Kinney, Ridgway, & Monroe, 2012). Researchers question why the fashion industry lags behind other industries in adopting sustainable initiatives. Benedetto (2017) found that a large barrier is the consumer's willingness to pay for sustainable fashion products. Ciasullo et al. (2017) found that customers were unlikely to pay for sustainable products 20% above the cost of conventional products.

McGoldrick and Freestone (2008) found that motivation for ethical purchasing is directly related to the level of consumer knowledge on social and environmental issues. In our highly competitive and materialistic society, education and awareness seem to take a back seat to strategic advertising and low market prices (Boltröm & Michelitti, 2016).

A continuous supply of low-priced, low-quality items not only encourages increased consumption but also fosters a disposal culture (Birtwistle & Moore, 2007; Domina & Koch, 1999). Textile waste is growing the fastest among all household waste materials (Ulasewicz & Esmus, 2016). Those studying the flow of textile goods have found that the majority of discarded textiles end up in landfills (e.g. Dahlbo, Aalto, Eskelinen, & Salmenperä, 2017; Kirboe et al., 2012; CRT, 2018). In Sweden and Finland, 80% of used textiles are either landfilled or incinerated while only 20% are reused or recycled (Dahlbo, Aalto, Eskelinen, & Salmenperä, 2017; Paras & Pal, 2017). In the U.S., only 15% are reused or recycled (CRT, 2018). A wealth of studies has explored textile disposal rates in reference to consumer behavior (Birtwistle & Moore, 2007; Domina & Koch, 1999; Joung & Park-Poaps, 2013; Norum, 2017; Weber, Lynes, & Young, 2017). These studies highlight a lack of environmental awareness and understanding among participants, particularly pertaining to the textile recycling process. All things considered, increased textile waste is linked to increased consumption and in turn, cultural values and lack of consumer awareness.

There is a general environmental hierarchy for managing textile waste. Reuse is the preferred diversion option as it requires the least amount of resources. This is followed by various recycling methods, incineration using energy recapture, incineration without energy capture, and lastly, disposal in landfill. Textile fibers, the majority of which are synthetic, can

remain in landfills for up to 200 years, emitting more carbon dioxide than plastics as they deteriorate (Krause, Chickering, Townsend, & Reinhart, 2016; Turner, Williams, & Kemp, 2015). Yacout and Hassouna (2016) conclude that incineration is less environmentally damaging than landfilling, particularly if energy capture is used. Indeed, the amount of extractable energy in textiles exceeds that in wood and paper (EC, 2017). As for the alternative disposal methods, there is a net energy benefit to recycling - 65kWh is saved for every kilogram of cotton that is recycled and 90kWh is saved for every kilogram of polyester recycled. (Wooldridge et al., 2005; Dahlbo, Aalto, Eskelinen, & Salmenpera, 2017). However, these studies operate under the assumption that recycled clothing replaces virgin material, which has not been confirmed by the scientific community. In any case, the consensus in the literature appears to be that more effort should be taken to divert textiles from landfills, adhering to the higher rungs of the environmental hierarchy.

1.3 Textile Diversion

Beyond reuse applications, textiles are known to be nearly 100% recyclable (e.g. Hawley, 2006; Norum, 2017). However, there are many barriers to textile recycling; the majority of textiles produced today are not designed for recycling. Textile recyclability inevitably depends on the fiber; polypropylene and polyester have been found to be the most recyclable in today's markets, followed by acrylic, cotton, wool, viscose and nylon (Muthu et al., 2012). Blended fibers also impacts recyclability; fibers must be extracted and recycled in their pure forms (Peterson, 2015). Therefore, fiber-to-fiber recycling is often not cost-effective. Inevitably, the ability to recover textile waste depends on the material, technology, and market price for recovered textiles (Wang, 2010).

Textiles have become an important commodity in global recycling markets; however, markets are constantly shifting and there is an urgent need to establish more robust end markets (Waste and Resource Action Plan [WRAP], 2016). Outside of landfills, charitable organizations are the primary outlet for discarded textiles. The majority of collected textiles are resold either domestically or through export markets (Claudio, 2007; Hawley, 2006). *Recycle grade textiles*, as opposed to *reuse grade textiles*, cannot be reused for their original purpose and are either ragged and used as wiping cloths, shredded and used as filler/padding, or broken down into individual fibers and used in the production of new goods (Chenoweth, 2018; Hawley, 2006; Wang, 2010). The two former techniques involve *down-cycling* textile waste to produce material of lower quality while the latter involves *upcycling* textile waste to produce material comparable to that made using virgin material. Markets that upcycle textiles are less common given that they require sophisticated fiber-to-fiber technology (Peterson, 2015). End markets for recycle grade textiles are characterized by high entry barriers, mainly in the form of high capital costs for processing infrastructure. As such, these markets remain relatively small scale compared to textile reuse

Figure 1 Market price for recovered textile (Source: WRAP, 2016).

activities. The market for recovered textiles has also softened over the last few years (see Figure 1), which further disincentives current and potential industry practitioners from diverting textiles, particularly recycle grade textiles. In effect, there is potential for growth within the
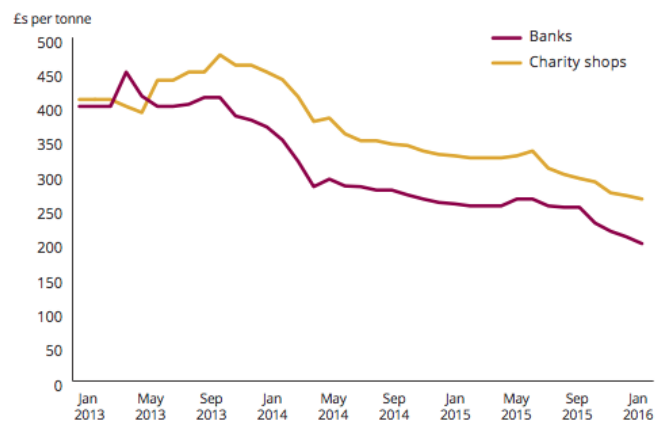
textile recycling industry especially in terms of recycle grade procurement and developing fiber-to-fiber technology further (Peterson, 2015; WRAP, 2016).

Collection also remains a core issue within the textile recycling industry and is one of the largest barriers inhibiting higher levels of diversion (Ulasexics & Esmuc, 2016). A handful of studies have looked at the benefit of including textiles in curbside collection programs. Domina and Koch (2002) found that increased access to curbside recycling led to a significant increase in the amount of *post-consumer textiles* collected. Daneshvary and Schwer (1998) concluded that public support for textile recycling programs is influenced by existing recycling habits, which suggests that jurisdictions with relatively high diversion rates can also expect to have high textile recycling rates. Though still in its infancy, curbside textile recycling may play a role in increasing residential textile diversion. However, the case for curbside has not yet been made for non-residential waste as no papers have been published on this topic.

Textile waste generated by ICI activities is targeted through other means. Reverse logistics refers to product returns by either the consumer, retailer, distributer, or supplier (Shen & Li, 2015). Reverse logistics increases the circularity of the supply chain as it integrates recycling systems directly into the chain (De Brito & Dekker, 2004). Incentives for closing the production loop can be financial (Kurata & Yue, 2008) or regulatory as reverse logistics can form part of *Extended Producer Responsibility (EPR)* legislation (Akdogan & Coskun, 2012). Collection is again a barrier to the success of reverse logistics schemes. Sas et al. (2015) explored the reverse logistics framework of the carpet industry in the U.S. Material recovery networks were characterized by high capital, maintenance, and transportation costs, thus materials needed to be collected and processed in large volumes for the operation to be economically viable. When

done efficiently, reverse logistics can increase non-residential textile diversion, though this issue demands further research and experimental trials (Akdogan & Coskun, 2012; Shen & Li, 2015).

Among retailers, there has been a surge in clothing buy/take-back schemes and second-hand retailing, which are examples of voluntary EPR. These schemes are highly variable among industry practitioners. Shen (2014) studied H&M's return policy program, whereby consumers are given the incentive to return worn products for a discount on future purchases. H&M stores have also served as drop-off locations for post-consumer textiles intermittently since 2013 (Shen, 2014). Other practitioners in this area include Eileen Fisher, Marks & Spencer's, and Levi's. The scientific consensus is that post-retail EPR is still an emergent industry that lacks established best management practices (Fletcher, 2008; Hvass, 2014). As it stands, EPR of post-retail textiles is a relatively new exploit among retailers with the potential to become an integral part of SSCM.

Several jurisdictions have been increasing their textile diversion efforts in recent years. Of note are the Nordic countries who have commissioned many in-depth studies aimed at increasing the circular flow of textiles (e.g. Kirboe et al., 2012; Paras & Pal, 2017). Though they are few and far between, several jurisdictions in the U.K. and U.S. have implemented residential curbside collection programs (Woolridge et al., 2005). In April 2017, the city of Markham banned textiles from disposal in landfill, the first to do so in North America. In tandem with the ban, the city established the Markham Textile Recycling Program and multiplied the number of drop-off locations (Markham, 2016; RCBC, 2017). Elsewhere in Canada, Metro Vancouver is currently considering a textile disposal ban for 2018 (Metro Vancouver, 2017). Academic

sources on these events are limited as textile management at the jurisdictional level is a relatively new endeavor compared to other recyclable materials. The existent academic literature highlights the need for government intervention in the form of sound waste policies to increase textile diversion (e.g. Dahlbo et al., 2017; Kirboe et al., 2012; Paras & Pal, 2017). Voluntary EPR and other SSCM schemes cannot combat textile waste alone; systematic change and coordination among stakeholders is required to advance textile recycling in its entirety (Boltröm & Michiletti, 2016). In effect, public procurement is poised to play an integral role in enhancing textile diversion and moving towards CE.

2.2.1 Nova Scotia

Nova Scotia is known as a leader in solid waste diversion among Canadian jurisdictions (e.g. Wagner, 2007; Wagner & Arnold, 2006). In the early 90s, when many countries were approaching landfill capacity, Nova Scotia enacted the *Solid Waste Resource Regulations*, which banned many recyclable items from landfills (*SWRR*, 1995, s 102). The regulations also mandated EPR programs for banned items including glass and beverage containers, dairy packaging, tires, paint, and electronics. These regulations were part of the province's *Solid Waste Resource Strategy,* which set a disposal rate target of 300kg/person/year by 2015, a goal that was later adopted into the *Environmental Goals and Sustainable Prosperities Act* (2007) (EGSPA, c. 7 s. 1). The province also established the Resource Recovery Fund Board (now Divert NS) as an independent body to manage many aspects of the strategy including the beverage deposit-refund system (NSE, 2008). Today, Nova Scotia has a disposal rate at almost half the national average, active landfills have reduced by 75% (from 40 in 1995 to 7 today), and 3,300 jobs have been created in the waste-resource sector since the strategy's inception (NSE, 2008;

Richter et al., 2017). Indeed, there is a successful legacy of solid waste management in Nova Scotia compared to the rest of Canada and North America as a whole (Goodick, 2003).

As in other jurisdictions, textile diversion remains a relatively new endeavor for Nova Scotia. Textiles are not banned from disposal in Nova Scotia and currently account for 12% of the municipal waste stream (Divert NS, 2011; 2012; *SWRR, 1995, s 102).* Residents are instructed to dispose of their fabrics, footwear, carpets, furniture and other bulky textiles in the garbage stream (Davidson et al., 2011). Textiles fall into the category of composite items, which "present challenges for recycling programs because in order to be recycled they need to be separated into their individual components" (Hiscock, 2013, p.18). There are voluntary collection systems for textiles in Nova Scotia, which are headed by the Association or Textile Recycling (AFTeR), a collaboration of six non-profit and for-profit organizations including the Diabetes Association, Value Village, and the Salvation Army (AFTeR, 2014). The organizations collectively divert approximately 7,000 of the 37,0000 tonnes of textile waste the province generates each year (19% estimated diversion rate). In 2016, one Nova Scotian county added textiles to their residential curbside collection program and have since achieved a 2% diversion rate with the potential for more (personal communication, J. MacFarlane, March 6, 2018). Textiles are arguably the next frontier in solid waste diversion in Nova Scotia and elsewhere. However, as an emergent area of interest, the issue demands further research to understand the flows of non-residential textiles within the province.

2.3 Knowledge Gaps

Little 3rd party research has yet been done to date on textile waste diversion in Nova Scotia. Current data is limited to governmental and non-governmental organization publications (e.g.

AFTeR, 2014; Divert NS, 2011; 2012). The primary resource for textile data is provincial waste audits commissioned by Divert NS, which do not sample beyond the landfill level. AFTeR is also not yet a resource for sub-regional textile data as they are still in the process of consolidating resources, collaborating with municipalities, and standardizing their public messaging (personal communication, Bob Kenney, NSE, September 21, 2017). As it stands, the methods for disposing of ICI textiles waste remains unclear. Given that the ICI sector accounts for approximately half of Nova Scotia's textile waste, there is a need to explore the issue of ICI textile waste at a sub-regional scale (Divert NS, 2011; 2012). Such research stands to advance waste management policy, enhance the sustainability of local supply chains, and increase textile diversion in Nova Scotia.

2.4 Conclusion

The literature indicates there is a high environmental burden associated with the production, usage, and disposal of textiles. Textile diversion is a relatively new endeavor among both governmental jurisdictions and private sector firms. There is a consensus that enhanced efforts on the part of industry, governments, and consumers to increase textile diversion from landfills would be beneficial. Nova Scotia is a leader in solid waste management among developed economies and ICI textile waste is not yet well understood in the province as there is a paucity of on the flows of non-residential textile waste in Nova Scotia.

3. Methods for Data Collection

Twelve organizations in and around Halifax who generate textile waste were identified. Data collection took the form of in-person interviews with mid-level managers (or equivalent) who

oversee textile usage and/or disposal at the organization. To provide background information, five other interviews were conducted with waste management experts and other professionals involved with textiles and textile waste across Nova Scotia. The information gained from the interviews was qualitatively assessed and underlying themes were discussed followed by implications for future research. The details of the methods used in this study are offered below.

The study population is ICI organizations who produce textile waste in Nova Scotia with a particular focus on the population center of Halifax. Halifax it is the metropolitan hub of Nova Scotia and has a robust ICI sector (with the exception textile manufacturers). Four organizations were included from outside the Halifax area.

This study aimed to interview representatives from as many organizations as possible and intended to focus on relatively large waste generators. However, there is currently no method for identifying large generators of textile waste in Nova Scotia as commercial waste streams are audited at municipal landfills. The problem is compounded by the fact that multiple collection areas can feed into a single one of Nova Scotia's seven landfills (Divert NS, 2012). It can be assumed, however, that large textile users may generate large amounts of textile waste. For example, it is well known that hotels use large quantities of textiles in their operations e.g. tablecloths, bedding, napkins (Ulasewicz & Baugh, 2013; Ulasewicz & Esmus, 2016). Therefore, this study employed non-probabilistic purposive sampling (Tongco, 2007), aiming to recruit interviewees from organizations who use relatively large amount of textiles. Snowball sampling (Marshall, 1996) was also employed to a lesser degree.

There were two categories of interviewees and the sampling design differed slightly

between them (see Table 1). The number of interviews was determined based on time constraints inherent to a semester-long study.

Table 1 Interviewee categories, examples, number of samples, and geographic containment for sampling.

Category	Examples	# Samples	Sampling area
1. Representatives from ICI organizations	• Operations mangers • Facilities managers	12	Nova Scotia, focus on Halifax
2. Waste management stakeholders	• Regional waste coordinators • Recycling officers • Textile researchers and designers	6	Nova Scotia

3.1 Category 1 Interviewees

Interviews were held with representatives from ten organizations. Finding the appropriate individual(s) to interview sometimes required contacting the organization through their public communication channel. These individuals needed to be able to attest to the textile management process at the organization. Potential interviewees were sent a recruitment letter (Appendix A), which provides general information about the study and requests an interview. An interview consent form accompanied the letter (see Appendix B). If it was not signed electronically, interviewees were given a hard copy of the consent form to sign before interview proceeded. Data collection took the form of semi-structured interviews of approximately 30 minutes' duration each. Interviews began by exploring research questions 1-3, those that directly related to the textile waste handling procedures at the establishment. The remaining time was dedicated to research questions 4 and 5, such as whether there should be increased effort to divert textiles in the province, what are the incentives to diverti textile waste at their organization and what are the barriers they face (see Appendix C for a comprehensive list of

interview questions). Interviewees were given the option of the interview being audio recoded or not. In-person interviews were preferable, though three took place over the phone. Unfortunately, phone interviews could not be recorded and detailed notes were taken in place.

The consent agreement between the research and ICI managers stipulated that the information could not be attributed back to the individual. Thus, the information gained was only reported in aggregate form and without disclosing interviewee names or organizations. This was done to allow interviewees the freedom to be more forthcoming and to share their opinions relating to textile waste. Participants could withdraw their participation at any point during or after the interview until April 20th, 2018, when a final thesis draft was due for submission.

Data from two organizations was collected informally as interviews with representatives were not possible. These representatives offered publically disclosed information only and no opinion questions were prompted.

3.2 Category 2 Interviewees

To provide background information on ICI textile waste in the Nova Scotia, six other 30-min semi-structured interviews were also carried out with experts and other textile waste management professionals in Nova Scotia. These include, but are not limited to, recycling officers, waste management coordinators, and other professionals with expertise in textiles and textile waste management. Participants were contacted based on their connection to and knowledge of textile waste diversion in Nova Scotia. Participants were also identified using snowball sampling given that waste management stakeholders tend to run in the same circles (Marshall, 1996). Potential interviewees were sent the consent form beforehand via email

(Appendix D). Preliminary interview questions gauged their relation to and understanding of textile waste management in Nova Scotia. Further questions addressed research question 4 and ventured for information on future waste management strategies for targeting textile waste in Nova Scotia, particularly for targeting ICI textile waste. The general outline for these interviews can be found in Appendix E. Again, interviewees were given the option of the interview being audio recoded or not. These interviews were not confidential as interview content was directly related to the individual's job capacity. However, interviewees have the option to refuse direct quotes and to withdraw their participation at any time until April 20th.

3.3 Analysis

Recorded interviews were transcribed the transcripts qualitatively assessed. Though some questions involved quantitative and categorical data (e.g. waste quantities, disposal options), the intent was to keep questions as open as possible so as not to limit interviewee responses. Thus, no *a priori* coding was used. In keeping with the exploratory nature of this study, data analysis was guided entirely by *a posterior* coding. This was used to identify underlying themes in the dataset and to establish an inductive framework for qualitative data analysis (Silverman, 2015).

This study strives for catalytic validity. Disjunction, untruthfulness, and inaccuracy among respondent answers was minimized by informing participants that they should not provide answers if they are inaccurate, instead venturing for why such information would be flawed. While qualitative data collection methods such as interviews will always carry respondent bias (Silverman, 2015), there is a systematic approach to the interview structures.

Each interview involved the same general questions (with the exception of some special case category 2 interviewees) and the study included a diverse set of participants.

4.0 Data Collection – Results and Discussion

Table 1 profiles each organization category in terms of its textile discard types, discard rates, and disposal pathways. Note that turnover/discard rates were given as approximate and were often unknown or unavailable.

Table 2 Summary of ICI textile waste types, turnover rates, and disposal methods for each type of organization.

	Types of textile discards (not exhaustive)	Turnover/discard rates	Disposal options employed
Hotels (3) # employees: - 295 - 200 - 115	- Bedding (sheets, blankets, pillowcases) - Towels (hand, face, bath, pool)	5-10% average (20-25% during peak season)	- Reused as rags - Bought by or donated to staff - Donated to community partners - Donated to AFTeR members
	- Banquet linen	<5%	- Donated to community partners - Landfilled
	- Uniforms	-	- Bought or kept by staff - Landfilled - Donated to community partners - Donated to AFTeR members
	- Cleaning cloths/rags	-	- Landfilled
	- Curtains and other decorative goods	During renovations	- Sold to community partners or other hotels
Hospital supplier (1) # employees: - 110	- Bedding (sheets, blankets, pillowcases) - Patient linens - Bath towels	3%	- Reused as rags - Donated to community partners - Donated to AFTeR members
	- Incontinent pads		- Donated to animal shelters
	- Surgical & pediatric linens	-	- Stockpiled for donation to disaster relief
	- Cleaning cloths/rags	-	- Landfilled
Universities (3) # students: - 18,000 - 5,000 - 1,000	- Bedding (sheets, blankets, pillowcases) - Towels (hand, face, bath, pool) - Banquet linen	<2%	- Reused as rags - Landfilled - Donated to community partners - Donated to AFTeR members
	- Uniforms	Negligible <1%	- Bought or kept by staff - Stockpiled - Landfilled

	- Scrap and other fabric remnants	Variable	- Donated to AFTeR members - Landfilled
	- Cleaning cloths/rags	-	- Landfilled
	- Curtains	Negligible <1%	- Landfilled
Retailers/ clothing distributors (3) # employees: - 50 - 40 - 3	- Pre-consumer textile goods	-	- Discounted and sold in-store - Discounted and sold at warehouse sales - Sold to consignment or second-hand stores - Donated to staff, shelters, or charities - Donated to AFTeR partners
Manufacturers (2) # employees	- Pre-consumer cutoffs/scraps	100%	
- 550		70-80 tonnes/year	- Landfilled
- 100		38-45 tonnes/year	- Sold to US recycler for insulation - Stockpiled - Landfilled

4.1 Management Practices at ICI Organizations

It was found that textiles were informally managed among organizations. Many interviewees highlighted the lack of internal standards for managing textile waste beyond quality control standards for hotel and hospital linens. As a result, textile waste management was not as well established as other sustainability initiatives among organizations, such as water and energy conservation efforts. As there were no precedents or formal disposal process, management practices were very diverse and diversion efforts were driven primarily by individual actions and initiatives. Organizations who employed environmentally-conscious individuals often procured more alternative disposal avenues and thus reported landfilling negligible to zero textile waste. These individuals would personally find destinations for textile discards produced by the organization, citing personal responsibility towards the community and environment. In effect, the onus of textile waste management was often found to fall on individuals or small groups of individuals working at the organization.

No matter the type, almost all organizations employed alternative management practices to some degree. There was a list of preferred disposal methods - a pseudo waste hierarchy for textile discards. Firstly, discards that could be salvaged as rags were either reused on-site or donated to community partners for usage or for processing and reselling as an extra funding source. As a result, organizations typically did not need to purchase new rags. Discards of relatively higher quality were given to local shelters, schools, charities, and other community organizations and charitable initiatives. In many cases the organization coordinated delivery themselves. These community partnerships were often secured by a staff member or else a community member would contact the organization directly to inquire about available discards. A less common diversion option was to deliver discards to AFTeR members. This was reportedly used when local options were unavailable for the particular type of discard. When all alternatives options were unavailable or exhausted, often as a result of oversupply, discards would either be stockpiled at the organization or in some circumstances, landfilled, though this was reported as a rarity with the exception of rags, scraps, and badly damaged/degraded materials (in essence, for recycle grade material).

4.2 Incentives and Barriers to Divert

There is a direct financial incentive to divert as much ICI textile waste as possible from landfill. Firms must pay for solid waste disposal; the commercial tipping fee is approximately $125 per tonne at HRM's landfill (ESSC, 2017; personal communication, ReGroup employee, April 5, 2018). One organization reported saving $300 per month, $3,600 per year, in tipping fees since they began exploring alternative disposal streams for their discards. The incentive to divert was stronger if community or AFTeR members were willing to coordinate the collection process

themselves. For organizations who produced relatively small amounts of discards, there was an apparent and usually unquantified diversion threshold - a point where the hassle to divert textile waste outweighed the tipping fees. It is at this point where textiles were disposed in landfill.

There was another financial incentive to minimize textile waste; with the exception of retailors and manufacturers, textiles must be replaced as they are discarded. Prices ranged from $100,000/year to replace textile discards at a single hotel to over $100,000/month at a single hospital. There was thus an incentive to keep textiles in circulation for as long as possible; however, this conflicted with industry quality standards. Hotel guests expect a level of quality and aesthetics that repaired linens cannot deliver (hotels offered no on-site repair). While hospital and University linens lend themselves more easily to repair, the recovery rate of damaged textiles has significantly decreased over the years given that buying new items has become the more cost-effective option. It was also highlighted in the interviews that the quality and usable lifetime of some types of textiles used in ICI operations (e.g. linen) has decreased over time, which has decreased their reparability and increased turnover rates.

Beyond the incentive to avoid landfill tipping fees, the organizations studied derived little to no financial compensation from using alternative disposal methods. Where the burden was on one individual, the incentive was often described as a personal responsibility. For example, patient clothing often got mixed in with hospital and long-term care facility laundry. In the past, these textiles would have been landfilled (200-300 lbs/week), but now they are being laundered and returned to their owners due to the initiative of one employee.

It was noted that the hospitality industry utilizes leadership goals as incentives to divert; among the hotels studied, quotas limited how many stained items could be discarded and thus maximized the amount put back in circulation (50% recovery rate target). For retailors, there is a clear incentive to sell off all merchandise, whether in-house or through other alternative channels listed in Table 1. Upholding the values of the organization and maintaining a reputable public image was also identified as an incentive to divert ICI textile waste.

Another underlying theme was the lack of organization-AFTeR partnerships. Partnerships with local charities and other community service organizations were more common than those with the relatively larger charities of AFTeR. While many organizations had reached out to AFTeR at one point or another, only one had an on-site bin managed by an AFTeR charity. At two others, AFTeR was their outlet for unbranded uniforms, scraps, and relatively low-quality material. Further demand for AFTeR partnerships, including the need for on-site regulated bins, was variable among organizations but low overall. Reasons for this included the following:

- Expressed desire to donate within the immediate community

- Desire to know first-hand the destinations and purpose of donations

- Unaware/unclear what material is accepted by the various AFTeR members

- Unaware of the recycling process and end markets for scraps and low-quality goods once donated to AFTeR (lack of transparency among AFTeR members overall)

- The particular kind of discard was not accepted by any AFTeR members as they had no market for it (mainly larger quantities of scraps from manufacturers)

- Existent management system works well as-is

The above are reasons why the majority of organizations prioritized local streams. These reasons can potentially be inhibiting greater diversion of lower-quality and scrap textiles produced by ICI organizations. With the exception of one manufacturer and all ragging activities, none of the alternative streams utilized by the organizations to manage their discards had the capacity to process recycle grade material. Indeed, the majority if ICI textile waste was donated for reused as-is. Among manufacturers studied, one had in the past secured an end market for their scraps; however, this US market – which recycled textile waste into automotive insulation – had closed its doors to accepting any more scraps and was unable to renew the contract with the manufacturer. As such, the scraps were being stockpiled at the organization in hopes of the market opening again. Another manufacturer had also lost its US buyer and was forced to landfill 100% of their cutoffs. It was found that AFTeR cannot accept larger quantities of scraps unfit for reuse as rag as they cannot currently market them. In the meantime, they currently accept smaller amounts – one relatively small generator began bringing scraps to an AFTeR member after discovering that they accepted small amounts of scrap material.

Another problematic area for ICI organizations was uniforms. Uniforms present a reuse challenge as many are branded with the name of the employee or organization. Branded uniforms could not be reused by the alternative streams and were either stockpiled or landfilled. In some cases, the onus of disposal was passed along to employees who were either allowed to keep their uniforms or were required to purchase them. Employees were advised not to donate branded uniforms as it presented a security issue. In effect, organizations and their employees need better access to markets that can recycle special materials such as branded work attire.

Barriers ICI organizations faced in disposing of their textiles included the lack of procurement for scrap, uniforms, and other recycle grade textiles. There is a need to expand recycling options and increase awareness surrounding these types of discards. In addition, future recycling programs need to account for the material which, according to organizations, does not warrant diversion at current discard rates. Relatively small amounts of textile waste must also be addressed as negligible material for one ICI source is no longer negligible when combined with the waste from all ICI generators in Nova Scotia. The zero-waste business model should be more actively explored with closed-loop diversion initiatives explored by industry and municipalities.

4.3 Study Limitations

This study carries several limitations due to sampling design. First, the sampling process may carry researcher bias in that personal or professional reasons may have influenced the organizations and interviewees that were chosen to participate. This was minimized by initially reaching out to a large number of potential participants during the recruitment process. Second, only 12 organizations and 5 organizational types were studied, with only 1-3 organizations representing each type. The natural next step is to survey a much large set of ICI organizations across Nova Scotia to increase the sample size. Third, only 1-3 representatives were interviewed from each organization. In the future, consulting more individuals from each organization or using focus groups involving multiple staff members would allow for a more in-depth understanding of textile waste management at the organizations.

There are several other limitations to this study that may have impacted the results. The data analysis process remains subject to researcher bias in that thematic coding requires

interpretation by the coder, which may have influenced the themes that emerged. This was minimized by remaining as objective as possible throughout the coding process and by constantly reviewing the transcripts in developing the interview themes. The results are also subject to respondent bias; interviewees may not have known or have been completely qualitatively or quantitatively forthcoming about the textile waste management process at the organizations. Finally, this study was predisposed to solicit participation from more environmentally-conscious interviewees and organizations thus the results may not represent the true reality of ICI textile waste in and around Halifax.

5.0 Jurisdictional Review

To inform the primary data, a jurisdictional literature review of ICI textile waste management in other developed economies was undertaken, scoping other Canadian, U.S., and European jurisdictions with stand-out initiatives including examples of markets for ICI textile discards. Developments in this are presented below.

5.1 Canada

Nova Scotia

There is currently one county in Nova Scotia that collects textiles curbside in their dual-stream system. In Colchester, textiles are collected in the same bag as paper and sorted on the fiber line at the Material Recovery Facility (MRF) (personal communication, J. MacFarlane, March 6, 2018). The curbside service applies to residences only; however, commercial businesses may drop off their unwanted textiles at the MRFs for a fee of $92.50/tonne (vs. $113/tonne for solid waste). Currently, the Colchester recycling program does not accept scraps from either

residential or ICI sources. Stakeholders are actively seeking a market for this material, which would allow them to capture production waste generated by manufacturers in the area (personal communication, J. MacFarlane, March 6, 2018).

An NS-based cloth diaper service keeps cloth diapers in circulation for as long as possible and displaces disposable diapers (personal communication, D. O'Sullivan, March 23, 2018). When the material becomes degraded, mainly from repeated washing, they are reused as rags by local mechanics. The company is also looking to collaborate with other private entities and municipalities on a province-wide diaper rental service, which would be the first of its kind (personal communication, D. O'Sullivan, March 23, 2018).

Currently, there are no end markets for scrap or recycle grade material in Nova Scotia (Chenoweth, 2018). While some AFTeR members do accept this material at many of their drop-off locations, their business model is built on reselling, not recycling, used textiles. Recycle grade material is costlier to process and market. Therefore, textile collectors tend to minimize the amount of non-resalable items they accept, particularly that which cannot be marketed as rags. Recycle grade textiles that do get picked up by the collection network are exported (Chenoweth, 2018; personal communication, NS Value Village & Salvation Army customer service representatives, April 1, 108).

British Columbia

In Surrey, Trans-Continental Recycling Textiles Ltd. (TCRT) recycles 100% of incoming textile waste from residential and ICI sources, processing almost 30 tonnes per day (TCRT, 2015). This company has partnerships with many ICI organizations and provides regular on-site collection services. This company also collects and recycles uniforms and other textiles that require

special handling. Recycle grade textiles that cannot be reused as wiping rags are processed, baled, and sold to mills that re-spin the fibers into yarn. All material is processed and marketed in Canada (TCRT, 2015).

Debrand is another BC-based company that provides secure recycling of uniforms and other specialty items that cannot be resold due to security issues (Debrand, 2016). This company specializes in recycling as opposed to reuse - uniforms are collected, de-branded, shredded and then sent to a US partner who breaks them down into fibers. A large bulk of the material is marketed as insulation filler but other uses include padding for cars and sporting goods (Debrand, 2016).

Ontario

Markham has a city-wide textiles recycling program with a robust collection network of donation bins. Businesses as well as residents are instructed to use the donation bins; however, organizations must contact program partners to arrange special pick-up of larger quantities of ICI discards. In lieu of there being a disposal ban on textiles, the program also accepts and actively solicits recycle grade material from both residents and businesses (Markham, 2016).

Bank & Vogue, located in Ottawa, purchase textiles that are unsalable in thrift and retail stores. They also capture used linen and other household textiles. This company partners with ICI organizations to find domestic and international markets for post and pre-consumer textile spill (Bank & Vogue, 2017). Envirotex Recycling Inc. also compensates organizations for textiles that are unsalable in thrift and retail stores and offers free pick-up services. Linens, uniforms, scrubs and other cotton-based ICI discards are also accepted if they can be marketed as rags (Envirotex, 2011).

5.2 United States

The Council for Textile Recycling in a non-profit organization in the US whose mandate is to promote macro-diversion efforts among brands, retailors, governments, academics, and consumers (CRT, 2018). Many of their members are private sector recyclers who collect and market recycle grade textiles. Currently, they are working on a nation-wide campaign to increase awareness among U.S. consumers and increase the visibility of existing end markets to municipalities, brands, and charities (CRT, 2018).

New York

Beyond the extensive efforts to divert residential textiles, New York City has a ceiling on the amount of textile waste that is accepted as refuse in commercial curbside collection. Businesses whose waste composition is more than 10% textiles is required by law to manage it separately from other waste items (NYC department of sanitation, 2012). However, the NYC department of sanitation offers little by way of diversion options for ICI scrap material. In response, innovators like ThreadCycle and FabScrap were created to capture the scrap material produced by NYC's garment district. These companies provide a local market for pre-consumer scrap material; Threadcycle uses pyrolysis to make waste-derived fuel in the form of bio-char, syngas, and bio-oil while FabScrap collects, sorts, and markets reuse and recycle grade material, using fiber-to-fiber technologies wherever possible (FabScrap, 2018; ThreadCycle, n.d.)

San Francisco

As part of their zero waste initiative, San Francisco supports ICI textile waste diversion by connecting businesses with local recyclers and providing on-site collection bins. Businesses may also place recycle grade discards in commercial recycling receptacles. The city partners with

charities and private companies to find end markets for all textiles collected (San Francisco Environment, 2017).

5.3 Europe

It is the EU's priority to strengthen the higher rungs of the waste hierarchy, with EPR and disposal bans being considered across Europe (EC, 2017). Recently, EU ambassadors voted on waste policies that form part of the EU's CE package. Along with material-specific targets, one provision requires that member states provide separate collection for all textiles and hazardous waste (Cole, 2017). However, the EU also recognizes the role of waste-to-energy systems in cutting landfill waste and moving up the rungs of the environmental hierarchy (EC, 2017). WTE technologies are becoming more and more sophisticated and many EU states consider it a viable alternative to landfilling textiles. For example, Germany does not allow untreated waste to be disposed of in landfills, thus, all waste textiles that cannot be recycled are destined for energy recovery (Fischer, Gentil, Ryberg, & Reichel, 2013; Nelles, Grünes, & Morscheck, 2016).

The European Textile Services Associated is a coalition of over 35 organizations whose goal is to reduce the impact of textiles used in hospitality, healthcare, and industrial operations (ETSA, 2015). Participating organizations provide textile rental, repair, and waste management services to clients across Belgium, Denmark, Finland, Finland, France, Germany, Italy, Norway, Sweden, Switzerland, and the UK. The companies actively seek ways to reduce textile waste and enahnce the sustainability of the supply chain. Recycling efforts include partnering with a Slovakian company to produce automotive and insulation filler (ETSA, 2015).

France

In 2008, France establish EPR schemes for importers and producers of clothing, footwear, and household textiles (EcoTLC, 2016). This law applies to all importers and producers who market these good within the country and makes these actors accountable for the *end-of-life (EoL)* phase of their products. The scheme had almost 2,000 charity partners who aid in delivering programs on behalf of textile importers and producers. Robust collection and recycling programs have evolved as a result of this initiative, with only 5-10% going to landfill or incineration. Meanwhile, 25-30% of recovered textiles are actively recycled. The majority of material is recycled into building insulation and the resultant products are marketed across the Europe (EcoTLC, 2016).

Italy

In Italy, private recyclers like Green Line and Nuevo Fratelli Boretti collect pre-consumer textile spillage from Italy's clothing, cutting, spinning, and weaving factories. They collaborated with Italian designers to create the high-end product, Re.Verso^{TM}, which is a type of fabric made from reprocessed wool waste. This is the first and only fiber-to-fiber technology that reprocesses pre-consumer wool waste. The process produces 96% less CO_2 emissions than production using virgin wool and uses 76% less energy (Green Line, 2008; Nuevo Fratelli Boretti, n.d.)

Nordic countries

The Nordic Council of Ministers are strategizing on how to support EPR, business models, and R&D that finds new ways to recover textiles, particularly in terms of closed-loop recycling. Stakeholders are also considering a tax on the disposal of more hazardous textile waste, such as those that contain dyes costlier to manage (Watson et al., 2015).

Finland-based Pure Waste is another private recycler who captures textiles left over from the manufacturing process. The company produces and markets 100% recycled fabrics (Pure Waste, n.d.).

5.4 Beyond Recycling – Waste Prevention and Circular Economy

Beyond the urgent need for back-end recycling at scale, governments, special interest groups, private firms, and consumers alike recognize the need for more sustainable long-term solutions to address textile waste in all its forms (e.g. CRT, 2018; EC, 2015; EC 2017; Ellen MacArthur Foundation [EMF]; 2017; I:Collect, 2018). Waste prevention, as opposed to waste reduction and management, is widely recognized as the highest rung of the environmental hierarchy for all materials (Bartle, 2011; EC, 2017; Korhonen at al., 2018; Korolkow 2015). Waste prevention is a key aspect of CE that involves changing what is considered "waste" and instead viewing all material as a resource. Operating supply chains on a circular model stands to take pressure off landfills, lower primary resource and energy usage, reduce pollution, foster job growth, and grow local economies and communities (Korhonen at al., 2018).

An emergent business model that may play an integral role in the transition towards a circular textiles economy is the service model approach. Service models remove the burden of ownership from individuals and organizations, streamlining the recycling process and encouraging innovation among firms. For example, MUD Jeans, who are based out of the Netherlands, lease highly-durable low-carbon jeans to customers, repair them when needed, and reprocess them when they are no longer wearable (MUD Jeans, 2017). Clothing libraries, which offer monthly or yearly subscriptions to rent clothing, are also on the rise in the Europe, particularly in Sweden and the Netherlands (Björk, 2010; Esculapio, 2018; Peters, 2015).

Currently, clothing libraries mostly operate in the realm of formal wear and high-end fashion rental; however, rental services are becoming more widely available for all types of textiles, including baby, children's, and maternity clothing (e.g Denmark-based Vigga) (EMF, 2017; Vigga, n.d.). This model can also be applied to ICI textiles, such as uniforms. For example, Dutch Awareness owns and leases highly-recyclable work and corporate wear to organizations such as hospitals and hotels (Dutch Awareness, 2018). When undertaken locally, turning textile consumption into a service closely aligns with the principles of the circular economy approach to sustainability (Zamani, Sandin, & Peters, 2017).

In turn, CE and the sharing economy model go hand in hand with other best practices for eliminating waste and extending the textile lifecycle. WRAP has developed a guide for increasing the sustainability of garments, which contains best practices for U.K. manufacturers and distributors (WRAP, n.d) while the EU's Green Public Procurement guide outlines sustainable textile procurement for public authorities (Neto et al., 2016). Best practices include sourcing materials from renewable resources, procuring organic and compostable material, aiming for homogenous fiber content, and using technologies that address microfiber shredding while increasing material durability and recyclability (EMF, 2017; Neto et al., 2016; WRAP, n.d.).

Other promising trends that stand to advance CE include re-localization of supply chains (EMF, 2017), zero-waste goals among jurisdictions (CRT, 2018; San Francisco Environment, 2017), as well as a growing appetite for EPR among developed countries (Dubois, de Graaf, Thieren, 2016; EC, 2015; Gioux, 2014; Watson, 2015). However, as discussed in section 2.1, there are significant barriers inhibiting more circular supply chains within the textile industry

beyond industry front-runners. A recent report on the future of the fashion industry by the Ellen MacArthur Foundation, a pioneer of the CE movement, concluded that:

> Transforming the industry to usher in a new textiles economy requires system-level change with an unprecedented degree of commitment, collaboration, and innovation. Existing activities focused on sustainability or partial aspects of the circular economy should be complemented by a concerted, global approach that matches the scale of the opportunity (EMF, 2017, p. 2).

6.0 Future Work – Increasing ICI Textile Diversion in Nova Scotia

1. Increase industry and government involvement

This study found that diversion was spearheaded primarily by individuals within the organizations. Interviewees highlighted not only the lack of industry standards, but lack of provincial and municipal leadership with regards to textile waste management. More concerted efforts are needed at the organizational, municipal, and provincial level to remove the burden from individuals and increase the convenience of diverting textiles. Recommendations for future research are to conduct focus groups within organizations to work towards industry standards and to identify where increased collaboration with the municipality is needed. Future research should also look at the potential effects on the ICI sector of enacting a disposal ban or EPR regulation on textiles in Nova Scotia.

2. Expand domestic recycling markets

A lack of disposal options for uniforms, scraps, and other recycle grade textiles was identified as a barrier inhibiting higher levels of diversion among organizations. Managing recycle grade textiles is central to closing the textile waste loop in Nova Scotia.

Nova Scotia is not yet equipped to shred and recycle textiles domestically; any scrap received through the AFTeR collection network is sold to out-of-province markets (Chenoweth, 2018). This calls for a feasibility analysis of expanding local recycling markets in Nova Scotia to increase procurement for recycle grade textile waste.

3. Increase ICI uptake rate of current markets for recycle grade textiles

As discussed above, the lack of awareness and transparency of current recycling markets is a barrier for organizations to divert scrap and other recycle grade material from landfill. Further research should investigate the barriers inhibiting more partnerships between ICI organizations and AFTeR members. Increasing the visibility and transparency of current markets should also be a priority for municipalities and AFTeR members, including enhancing education initiatives aimed at both the residential and ICI sector.

4. Track end destinations and final impacts of ICI discards

This study only focused on the diversion efforts at one stage of the textile lifecycle. At this stage, diversion was aimed at delaying material arrival in landfill. The final destinations for textiles diverted by ICI organizations must be explored to quantify their end destinations and impacts.

5. Explore new management options for unrecyclable EoL textiles

A consistent source of waste among organizations was from the reusing of discarded textiles as rags. Rags can only be used for a limited amount of time before they reach the end of their usable lifetime and must inevitably be landfilled. This was particularly true when used in operations that left rags stained with grease and oil, which constitutes hazardous waste. While

the quantity of this material produced in Nova Scotia is currently unknown, the province should explore new markets for unrecyclable EoL materials as opposed to landfilling them.

7.0 Conclusion and Implications

In this study it was found that the responsibility of managing ICI textile waste falls primarily on individuals within organizations and that direction from industry and government was lacking. The majority of organizations studied were actively engaged in diversion efforts, employing alternative management practices, as opposed to landfilling, for disposing of ICI discards with the exception of rags, scraps, branded uniforms, badly damaged and other recycle grade materials. The incentives to divert were found to be financial, personal, or to uphold the principles of the organization.

The results of this study indicate a need to expand markets for recycle grade textiles produced by ICI generators in Nova Scotia and across Canada. There needs to be a more coordinated effort on the parts of governments, textile recyclers, and ICI organizations to increase procurement for recycle grade textiles. Awareness of current markets for recycle grade textiles should also be expanded within the ICI sector. In addition, the end destinations and impacts of textiles diverted by organizations should be explored further. Finally, the province should consider other disposal options for managing unrecyclable textiles to decrease the amount that goes to landfill.

Overall, this study found that there are opportunities to increase textile waste diversion within Halifax's ICI sector and Nova Scotia as a whole but it will not be without effort. This effort will require developing local supply chains, supporting and sharing recycling market research, consideration of approaches by other countries and a commitment to success

reflected in government waste policy and procurement. This pilot study has identified a number of areas where further data, government leadership, and organizational sharing would greatly facilitate success in the area of textile waste diversion.

Glossary

Circular Economy (CE): Aims to minimize the amount of virgin material input into a system by following a cradle-to-cradle approach to sustainability. This includes designing/purchasing goods for durability, reparability, and recyclability.

Down-cycling textiles: Involves the breaking down of textiles into their constituent elements, often producing lower-quality fibers, which are then reused for new purposes in textile-based products such as insulation or car seat filling.

End-of-life textiles (EoL): Degraded or damaged textiles unfit for reuse. EoL textiles are deemed recycle grade textiles and can be reprocessed and reused in the production of new goods.

Extended Producer Responsibility (EPR): A regulatory tool that makes producers accountable for the post-consumer stage of the product life cycle. This means either developing their own recycling/management program or funding a 3rd party to manage a program on their behalf.

Industrial, Commercial, and Institutional sector (ICI): Includes all operations outside of the residential and construction and demolition (C&D) activities. For example, schools, universities, hospitality and healthcare industries, and businesses outside of C&D.

Post-consumer textile waste: Textile waste produced by consumers, also known as pre-consumer spill. This includes residential and ICI textile waste with the exception of production waste i.e. pre-consumer waste.

Pre-consumer textile waste: Also known as production waste or pre-consumer spills. Pre-consumer textile waste is produced in the manufacturing/designing of new textile goods.

Recycle grade textiles: Lower-quality textiles unfit for reuse are categorized as recycle grade material, as opposed to reuse grade material, which does not necessitate reprocessing as such.

Reuse grade textiles: Textiles that can be re-used for their original/intended purpose. For example, reuse grade clothing is re-wearable.

Upcycling textiles: Transforming textile waste through redesigning or repurposing, creating products of higher quality or value; a form or textile waste reuse.

Appendix

Appendix A
SAMPLE INTERVIEW RECRUITMENT LETTER
REPRESENTATIVES FROM ICI ORGANISATIONS (CATEGORY 1 IN TABLE 1)

Contact name
Title of organization
Address of organization

Subject: Textile waste management in Nova Scotia

I invite you to be part of a study being completed through Dalhousie University on textile waste. We want to hear from you about what your organization does with its old textiles (linens, bedding, clothing, apparel, and footwear) when they are no longer able to be used for their indented purpose.

Your participation in this research will provide vital information for our project evaluating commercial, institutional, and industrial textile waste in Nova Scotia. The research serves to inform future waste management strategies in Nova Scotia aimed at expanding disposal options for textile waste. If you decide to participate, your name, job title, and your organization will all be kept confidential. Only the general characteristics of your Organisation will be included in the final study (size and type). The study will be made publically available in May, 2018.

If you would like your organization to be a part of this research, I would be interested in setting up an interview with you at your earliest convenience. Please see attached the interview consent form, which provides more detailed information on the study, the informed consent process, and what to expect from the interview.

Please do not hesitate to contact me if you have any questions or concerns. You may also contact my research supervisor Dr. Michelle Adams (Michelle.Adams@dal.ca) or Dr. Wright (Tarah.wright@dal.ca) who coordinates all Environmental Science thesis projects in the Faculty of Science at Dalhousie University.

Sincerely,

Emily Bibeau
Dalhousie University undergraduate
Department of Environmental Science
E: Emily.Bibeau@dal.ca T: (204) 999-7412

Appendix B
INTERVIEW CONSENT FORM
REPRESENTATIVES FROM ICI ORGANISATIONS (CATEGORY 1 IN TABLE 1)

Project title: Characterizing ICI textile waste in Halifax, Nova Scotia

Lead researcher: Emily Bibeau, Dalhousie University, (204) 999-7412, Emily.Bibeau@dal.ca

Supervisor: Michelle Adams, Dalhousie University, Michelle.Adams@dal.ca

Funding provided by: Divert Nova Scotia

Introduction

We invite you to take part in an undergraduate research study for an honors thesis in Environmental Science at Dalhousie University on textile waste management among Halifax's businesses and institutions. This study also involves waste management professionals/experts within Nova Scotia. Choosing whether or not to take part in this interview is entirely your choice. There will be no impact on you whatsoever if you decide not to participate. The information below tells you about what is involved in the research. You should discuss any questions you have about this study with your interviewer. Please ask as many questions as you like. If you have questions later, please contact the interviewer/lead researcher, Emily Bibeau.

Purpose and outline of the research study

We invite you to participate in an approximately 30-min interview about textile usage and management at your organization as well as your thoughts on textile waste management and textile waste diversion in general. Interview questions include (but are not limited to):

- *For what purpose does your organization use textiles in its operations?*
- *What disposal options are in place for textile waste at your organization?*
- *In your opinion, what can/should be done in Nova Scotia to decrease the amount of textiles that go to landfill?*

Please note that additional and/or follow up questions will be asked to supplement the general questions above and may change as the interview proceeds.

Consent process

The information collected by this study will be reported only in aggregate form, direct quotes will not be used, and your answers will not be attributed back to you; **your name and job title will be kept confidential and your answers will only be identified by establishment type** (e.g. hospital, hotel, restaurant, retailer, manufacturer, etc.) **and by establishment size**, measured by the number of employees. In the report, you and other interviewees will be referred to as managers (or equivalent) overseeing textile operations at the organization, no matter the type of organization. You are also given the option to have the interview audio recorded or not.

The information you disclose will be available for use in the final study and to inform future studies. You may decline to answer any and all questions posed during the interview. All data will be sorted at Dalhousie University on a secure computer. Should you choose to withdraw your participation, you may do so at any time during or after the interview has taken place and we will discard any and all information you provided. The withdrawal window ends on April 20th, 2018 when the final report is due for submission. If you wish to view the final results of our study, please let us know during the interview and we will gladly provide you summary of the study results or a copy of the full thesis once it is publically released on May 1st, 2018.

If you have any further questions, please feel free to contact me at Bibeau.Emily@dal.ca or by phone at (204) 999-7412. If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca

Signature page

Project title: Characterizing ICI textile waste in Halifax, Nova Scotia

I have read the explanation about this study and understand how the information I provide will be used. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I understand the general characteristics of my organization will be used to identify my answers as described above. I understand that I have been asked to take part in one interview that will occur at a location acceptable to me, and that there is an option of it being recorded. I agree to take part in this study. My participation is voluntary and I understand that I am free to withdraw from the study at any time before April 20th, 2018.

I agree to my interview being audio-recorded (circle one): Yes / No

_____   _____   _____

Name   Signature   Date

Note: The signature of a researcher or a witness is **not** required. Getting participants to sign two copies is **not** required, and in fact may compromise privacy if the participant's copy is not stored securely

Appendix C
INTERVIEW QUESTIONS
REPRESENTATIVES FROM ICI ORGANISATIONS (CATEGORY 1 IN TABLE 1)

Name of participant:

Affiliation:

Type of organization:
   a. Hospitality
       (hotel/restaurant/café)
   b. Retailer
   c. Healthcare provider
   d. Industrial
   e. Institution of higher learning

1. Does your organization use textiles
    in its operations?

2. If so, what kind(s) of textiles are
    used (e.g. towels) and for what
    general purpose? Please be as
    specific as possible.

3. Does your organization's
    establishment in Halifax produce any
    textile waste?

4. If yes, what is the primary method of
    handling textile waste produced at
    your organization's establishment in
    Halifax?

    a. Disposed in the garbage
    b. Self-hauled to
        collection/donation
    c. Collected on-site by a
        separate entity

   d. Other method:

       _____

       _____

5. If possible, please provide the
    closest estimate you can on how
    much textile waste your
    establishment produces per month
    or per year (e.g. 1 large garbage bag
    per month). Provide any reasons
    why you cannot provide an estimate
    or why the estimate you provided
    may be inaccurate.

6. If these questions were
    unsatisfactory in understanding how
    your organization manages its textile
    waste, please provide any other
    pertinent information:

7. Do you support adding textiles to
    the commercial curbside collection
    program in Halifax?

8. What are the barriers to increasing
    diversion at your organization?

9. Could your organization benefit in
    any way from increased diversion?
    Are there any existing incentives?

10. What can/should be done to
    decrease the amount of textile
    waste that goes to landfill in Nova
    Scotia?

Thank you for participating in this study. If you have any question or if you wish to change or withdraw your answers at any point until April 20th, 2018, you may contact Emily Bibeau by email at Emily.Bibeau@dal.ca or phone (204) 999-7412.

Appendix D
INTERVIEW CONSENT FORM
WASTE MANAGEMENT PROFESSIONALS (CATEGORY 2 IN TABLE 1)

Project title: Characterizing ICI textile waste in Halifax, Nova Scotia

Lead researcher: Emily Bibeau, Dalhousie University, (204) 999-7412, Emily.Bibeau@dal.ca

Supervisor: Michelle Adams, Dalhousie University, Michelle.Adams@dal.ca

Funding provided by: Divert Nova Scotia

Introduction

We invite you to take part in an undergraduate research study for an honors thesis in Environmental Science at Dalhousie University on textile waste management among Halifax's businesses and institutions. This study also involves waste management professionals/experts within Nova Scotia. Choosing whether or not to take part in this interview is entirely your choice. There will be no impact on you whatsoever if you decide not to participate. The information below tells you about what is involved in the research. You should discuss any questions you have about this study with your interviewer. Please ask as many questions as you like. If you have questions later, please contact the interviewer/lead researcher, Emily Bibeau.

Purpose and outline of the research study

We invite you to participate in an approximately 30-minute interview about your thoughts on textile waste management and textile waste diversion in Nova Scotia. More specifically, Halifax's non-residential textile waste generated by institutions, industry, and commercial establishments. Interview questions include (but are not limited to):
- *What do you know about textile waste diversion in general?*
- *How effective do you think the current collection bins are at diverting textile waste, particularly for that generated by businesses and institutions?*
- *In your opinion, what the barriers inhibiting textile waste diversion in Nova scotia, particularly among local institutions and businesses and what steps can be taken towards overcoming these barriers?*

Please note that additional and/or follow up questions will be asked to supplement the general questions above and may change as the interview proceeds.

Consent process

The information you provide will be used for background information for interviews with ICI managers and focus groups with their employees. **Participating means giving consent to use your name/title to identify your answers.** However, content will be directly related to your position and no questions will go beyond your professional capacity to answer thus there is minimal risk to you and to your organization. You are given the option to be quoted directly or not as well to allow the use of an audio recorder during the interview or not.

All the information you disclose will be available for use in the final study and to inform future studies. You may decline to answer any and all questions posed during the interview. All data will be stored at Dalhousie University on a secure computer. Should you choose to withdraw your participation, you may do so at any time during or after the interview has taken place and we will discard any and all information you provided. The withdrawal window ends on April 20th, 2018 when the final report is due for submission. If you wish to view the final results of our study, please let us know during the interview and we will gladly provide you a summary of the results or a copy of the final study once it is publically released on May 1st, 2018.

If you have any further questions, please feel free to contact me at Bibeau.Emily@dal.ca or (204) 999-7412. If you have any ethical concerns about your participation in this research, you may also contact Research Ethics, Dalhousie University at (902) 494-1462, or email: ethics@dal.ca

Signature page

Project title: Characterizing ICI textile waste in Halifax, Nova Scotia

I have read the explanation about this study. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I understand that I have been asked to take part in one interview that will occur at a location acceptable to me, and that there is an option of it being recorded. I understand that my name and title may included in the final study and that I have the option of being directly quoted or not. I agree to take part in this study. My participation is voluntary and I understand that I am free to withdraw from the study at any time before April 20th, 2018.

I agree to being directly quoted (circle one): Yes / No

I agree to the interview being audio-recorded (circle one): Yes / No

_____   _____   _____

Name   Signature   Date

Note: The signature of a researcher or a witness is **not** required. Getting participants to sign two copies is **not** required, and in fact may compromise privacy if the participant's copy is not stored securely.

Appendix E
INTERVIEW QUESTIONS
WASTE MANAGEMENT PROFESSIONALS (CATEGORY 2 IN TABLE 1)

1. What is your connection to/experience with textile waste?

2. Can/how how would you describe textile waste flows in Nova Scotia?

3. What can you tell me about textile waste produced by commercial buildings, institutions – such as universities and hospitals – as well as industrial textile waste?

4. What are your thoughts on curbside collection for textiles? Would you support adding textiles to the residential curbside collection program in Halifax? Could this method be used to target ICI waste streams as well?

5. What are some barriers to increasing diversion in Halifax and among ICI organizations in particular? In Nova Scotia?

6. Can companies, businesses, and institutions benefit from reducing the amount of textiles they dispose of in landfill? What kind of incentives would increase their diversion rates?

7. What can or should be done to decrease the amount of textile waste that goes to landfill in Halifax? In Nova Scotia?

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