Reducing Greenhouse Gas Emissions Through Consolidated Returns Shipments: A Retail Study

Happy Returns

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August 2018

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CERTIFICATION PAGE

Engineer Review and Certification

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Wilton Mui is an Environmental Engineer at Yorke with a B.S. in Environmental Engineering from the University of Florida, and a M.S. and Ph.D. in Environmental Science and Engineering from the California Institute of Technology. He is also C.P.P. with the SCAQMD. He has deep knowledge of instrumentation, measurement, and analysis aspects of atmospheric particulate matter from his graduate research. Since joining Yorke, he has gained familiarity with EPA, CARB, and SCAQMD air pollution regulations and compliance requirements. He has worked with clients in various operations, including aerospace, agriculture, aluminum processing, cement, correctional facilities, food processing, groundwater cleanup, pharmaceuticals, printing, semiconductors, and textiles. He has experience in emissions inventories and reporting, emission estimation techniques, and health risk analyses. His specialties include regulatory research, database management, data visualization, "big data" analysis, and programming with Microsoft Access and Microsoft Excel Power Query and Power Pivot.

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__________________________________ August 28, 2018

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1.0 EXECUTIVE SUMMARY

With more than 35 million tons of cardboard containers produced in the United States every year, the consumption of corrugated cardboard is a large and mounting problem that is exacerbated by the growth of online shopping [1]. The production and disposal of all this cardboard results in climate-changing Greenhouse Gas (GHG) emissions. A significant fraction of cardboard use from online shopping derives from high merchandise return rates and the inefficiency of individual return-by-mail shipments.

Happy Returns has created a new box-free return model designed to reduce the environmental impact of online returns. Returns are accepted, box-free, at a nationwide network of “Return Bars” at the beginning of the process and shipped in bulk in reusable packaging to nearby hubs for routing to the most efficient destinations. The box-free return model curtails the total distance traveled both for returns and resold refurbished items, as well as reduces the cardboard consumption required.

In this report, we rely on the U.S. Environmental Protection Agency’s (U.S. EPA’s) Waste Reduction Model (WARM) to quantify emissions reductions from the box-free return model and compare the outcome with the individual return-by-mail shipment model. Based on these calculations, the results estimate that on average, the box-free return model reduces the amount of GHG emissions associated with packaging by 0.12 pounds per item returned. The Happy Returns model also minimizes the amount of cardboard that would be required for return shipments – by nearly 73% in weight and 92% in area.

To underscore the significance of this impact, if an individual retailer with 1 million annual returns converted all their returns to Happy Returns’ new box-free return model, the GHG emissions reduction from reduced packaging alone would amount to 120,000 pounds per year.

2.0 BACKGROUND

Consumers are becoming more aware of the environmental impact of increased cardboard consumption associated with online shopping [2]. Amazon alone ships one or two packages per week to 42% of the shopping population, according to research from Walker Sands [3]. Invesp estimates that 30% of all online purchases are returned [4]. The cardboard packaging alone in which these online purchases are shipped can contribute millions of metric tons of GHGs and other related pollutants to the atmosphere, not to mention the emissions from transportation of goods from distributor to consumer.

Yet high return rates are endemic to online shopping. In the case of clothing and shoes, the bedroom has become the fitting room. Shoppers are less likely to review the fit or size descriptions and the instructions for use and care before deciding to purchase items. Items purchased online are four times more likely to be returned than products purchased in a store, according to internal data by Happy Returns.

Unfortunately, the outdated logistics infrastructure of returns was not designed for online transactions. In fact, the process is highly inefficient; each shopper's return for each retailer is sent in an individual box, oftentimes across the country. In addition, the infrastructure is both financially costly to the organizations that pay for the returns and environmentally costly to society.

Happy Returns has developed a box-free return model designed to reduce the environmental impact of online returns. In this model, returned items are deposited without packaging, aggregated at "Return Bars" at the beginning of the process, and shipped in reusable packaging to processing centers where they are routed to the most efficient destinations. The box-free return model minimizes the total distance traveled both for returns and resold refurbished items, as well as reduces the cardboard consumption required.

This white paper, the first in a series, relies on third-party calculations to estimate the GHG emissions associated with excessive packaging from online shopping product returns. In short, this paper quantifies the cardboard savings, and therefore environmental benefits, that can be realized from aggregating return shipments rather than shipping each item separately. Happy Returns' nationwide network of Return Bars, which consolidates masses of customer returns across many retailers into single, densely packed shipments using a combination of reusable packaging and bulk cardboard boxes, is the study's source for estimating the cardboard savings.

Future studies in this series will quantify:

- Tailpipe emissions reductions from routing returns through one centrally located hub versus multiple regional hubs; and
- Tailpipe emissions reductions from shipping densely packed consolidated returns rather than individual returns by mail.

3.0 METHODS

In the Happy Returns' box-free return model for handling online shopping returns, consumers deposit items at Return Bars. These Return Bars are located in shopping centers and can be part of shopping trips that would have otherwise occurred in the absence of a need to return products. From the Return Bars, the products are transported in 100% reusable packaging to a processing hub. Most items (75%) are either restocked in-place at the hub or shipped to another warehouse in reusable packaging. The remaining 25% of items are densely packed in pallet boxes to be shipped to another warehouse. It is this minority of returned items shipped in the pallet boxes that leads to consumption of new cardboard in the box-free return model.

Quantification of the changes in GHG emissions from this box-free return model, as opposed to individual shipping returns, is based on emissions factors from the U.S. EPA's WARM database [5]. WARM is a tool that uses industry-average GHG emissions to understand and compare lifecycle GHG consequences of various materials management options for common waste-stream materials. The most recent update to WARM (Version 14) is applied in this study.

3.1 Lifecycle Stages

The lifecycle of a product includes the following primary stages: 1) extraction and processing of raw materials, 2) manufacture of products, 3) transportation to markets, 4) use by consumers, and 5) end-of-life management [5].

Emissions from the consumer-use stage are not considered in WARM since that stage does not alter emissions from a waste management perspective [5]. Additionally, GHG emissions for non-durable goods (such as corrugated cardboard) are typically negligible in the consumer-use stage, unlike most durable goods (such as automobiles).

3.2 Materials Management Scenarios

WARM allows for the comparison of alternative materials management scenarios [6]:

- Source reduction, in which GHG emissions through the lifecycle are avoided as a result of reduced material consumption. In the case of corrugated cardboard, there are additional GHG emission reductions resulting from forest carbon sequestration.
- Recycling, in which GHG emissions are reduced, in most cases, through the production of material from recycled inputs instead of virgin inputs.
- Composting, in which GHG emissions are reduced through soil carbon storage, but emissions of methane (CH_4) and nitrous oxide (N_2O) are also increased from decomposition.
- Anaerobic digestion (producing biogas and digestate), in which GHG emissions are reduced by: 1) offsetting fossil fuel consumption through biogas combustion for energy, 2) digestate substitution for synthetic fertilizer, and 3) digestate soil carbon storage, but also increased through CH_4 and N_2O emissions from digestate processing and land application.
- Landfilling, in which GHG emissions are decreased through landfill carbon storage, but also increased through CH_4 emissions from waste decomposition (unless the CH_4 is captured and combusted for energy, thereby offsetting fossil fuel consumption).

- Combustion, in which GHG emissions are decreased through offsetting electrical demand from fossil fuel-combusting electrical generators.

Note that conversion of corrugated cardboard to CO_2 through decomposition or combustion are not considered to increase atmospheric GHG concentrations, since the CO_2 is biogenic in origin (wood pulp from trees) and is in constant flux between the biosphere and atmosphere. Rather, CO_2 from fossil fuel combustion is considered to increase atmospheric GHG concentrations, since this represents a practically permanent transfer of carbon from the lithosphere into the atmosphere.

This study compares the GHG emissions from end-of-life management, such as recycling and landfilling, of new corrugated cardboard used for individual return shipments against the GHG emissions from source reduction, since the box-free return model results in a decrease in corrugated cardboard consumption. WARM does not model corrugated cardboard composting or anaerobic digestion, since these waste management options are not generally considered for paper products [7]. Furthermore, this study does not consider the combustion waste management option, since waste-to-energy combustion is not a common disposal route in the United States.

3.3 Estimation of Material Use

WARM emission factors are based on metric ton CO_2 equivalents per short ton of material ($MTCO_2$eq/short ton). To quantify the difference in GHG emissions from reduction of corrugated cardboard use due to the box-free return model, the corrugated cardboard consumption in the absence of the box-free return model was estimated.

3.3.1 Individual Return Shipments

Calculation of the amount of cardboard used per individual return shipment requires certain assumptions regarding weights, densities and packaging dimensions. Internal Happy Returns data shows that the average item weight is $m_\mathrm{i} = 1$ lb and the typical number of items per return shipment is $n_\mathrm{ind} = 1$. According to the National Motor Freight Traffic Association (NMFTA), the average density of bulk cloth shipments is $\rho_\mathrm{bulk} = 10.81\ \mathrm{lb/ft^3}$ [8]. For this study the density of an individual return shipment is assumed to be only 10% less dense, or $\rho_\mathrm{ind} = 9.73\ \mathrm{lb/ft^3}$. It is also conservatively assumed that a cubic corrugated cardboard box is used for an individual return, thereby minimizing the amount of material consumed by individual return shipments. Thus, the area of corrugated cardboard required per individual return is:

$$A_\mathrm{ind} = 6\left(\frac{m_\mathrm{i} n_\mathrm{ind}}{\rho_\mathrm{ind}}\right)^{\frac{2}{3}}. \qquad \text{(Eq. 1)}$$

Internal Happy Returns data indicates that 60% of e-commerce consumers mail their returns in the same packaging in which the products were delivered, thereby not using additional cardboard. In other words, on average, 60% of A_ind would be from reused corrugated cardboard while 40% of A_ind would be from new cardboard. It is only the GHG emissions from production and disposal of the *new* cardboard consumed, $A_\mathrm{new,ind} = A_\mathrm{ind} \times 40\%$, that is considered in this study and is offset through the box-free return model.

The material for individual-returns packaging is presumed to be single-wall corrugated cardboard, with a grammage of $\rho_\mathrm{cc,ind} = 500\ \mathrm{g/m^2}$ [9]. Accordingly, the mass of new cardboard that would be consumed in the absence of the box-free return model is

$$m_{\text{new,ind}} = A_{\text{new,ind}} \times \rho_{\text{cc,ind}}. \qquad \text{(Eq. 2)}$$

3.3.2 Aggregated Return Shipments

The aggregated returns in the box-free return model that use new cardboard (25%) are transported in new Gaylord boxes (also known as bulk or pallet boxes). These boxes have dimensions of 48 in. x 40 in. x 36 in., and therefore a volume $V_{\text{tot,agg}}$ and surface area $A_{\text{tot,agg}}$ of 40 ft^3 and 70.7 ft^2, respectively. The material used for Gaylord boxes is typically triple-wall corrugated cardboard, with a grammage of $\rho_{\text{cc,agg}} = 1758 \text{ g/m}^2$ [10].

The number of items that can be transported in a Gaylord box is calculated as:

$$n_{\text{agg}} = V_{\text{tot,agg}} \times \frac{\rho_{\text{bulk}}}{m_{\text{i}}}, \qquad \text{(Eq. 3)}$$

The new cardboard area required per item transported, on average, is:

$$A_{\text{new,agg}} = \frac{A_{\text{tot,agg}}}{n_{\text{agg}}} \times 25\%, \qquad \text{(Eq. 4)}$$

The mass of new cardboard required per item transported is:

$$m_{\text{new,agg}} = A_{\text{new,agg}} \times \rho_{\text{cc,agg}}. \qquad \text{(Eq. 5)}$$

3.3.3 Net Material Reduction

These equations, 1 through 5, allow for the estimation of the per-item reduction in new cardboard usage associated from the box-free return model:

$$\Delta m_{\text{new}} = m_{\text{new,ind}} - m_{\text{new,agg}} = \left[40\% \times 6\left(\frac{m_{\text{i}} n_{\text{ind}}}{\rho_{\text{ind}}}\right)^{\frac{2}{3}} \rho_{\text{cc,ind}}\right] - \left[25\% \times \frac{A_{\text{tot,agg}}}{V_{\text{tot,agg}}\frac{\rho_{\text{bulk}}}{m_{\text{i}}}} \rho_{\text{cc,agg}}\right] \qquad \text{(Eq. 6)}$$

3.4 Source Reduction

In displacing the use of new cardboard for individual return shipments, the box-free return model serves as a means of source reduction. Source reduction decreases the emissions from raw materials acquisition and manufacturing (RMAM), which consists of GHG emissions from: 1) energy used during RMAM processes, 2) energy to transport materials, and 3) non-energy processes, i.e. the conversion of limestone into lime [7]. The RMAM emission factors in WARM includes the effect of retail transportation, which is the average emissions value from shipping the corrugated cardboard from manufacturing facilities to retail/distribution points.

It should be noted that transportation emissions from the retail point to the consumer are not included in WARM, and thus the decrease in GHG emissions from source reduction is likely underestimated.

In addition to the reduction in energy consumed, source reduction also results in increased forest carbon storage (FCS) in managed forests. Forests absorb and store atmospheric CO_2; due to source reduction, trees that would have been harvested are left standing. Detailed discussion of the methodology to calculate RMAM emissions and FCS can be found in WARM documentation [5, 7].

The WARM emission factors for source reduction are based on the current mix of 35% recycled inputs and 65% virgin inputs for corrugated cardboard production [7]. Table 3-1 lists the source reduction emission factors for RMAM (SR_{RMAM}), FCS (SR_{FCS}), and the net emission factor (SR_{tot}) used in this study, which are based on the current mix of inputs. The net emission from source reduction per item returned is

$$E_{\mathrm{SR}} = \Delta m_{\mathrm{new}} SR_{\mathrm{tot}} = \Delta m_{\mathrm{new}} (SR_{\mathrm{RMAM}} + SR_{\mathrm{FCS}}). \quad \text{(Eq.7)}$$

Table 3-1: WARM Source Reduction Emission Factors For Current Mix Of Corrugated Cardboard ($MTCO_2eq$/short ton) [7]

Emission Factors	RMAM for Current Mix of Inputs, SR_{RMAM}	FCS for Current Mix of Inputs, SR_{FCS}	Net Emissions for Current Mix of Inputs, SR_{tot}
Corrugated cardboard	-0.87	-4.73	-5.60

Note that source reduction emission factors only account for the effects of GHG emissions upstream from the point of waste generation. If new cardboard were produced for individual return shipments, the GHG emission repercussions of the eventual disposal of that new cardboard – i.e. recycling and landfilling – must also be considered.

3.5 Recycling

Similar to source reduction, recycling also displaces the use of new cardboard for individual return shipments. The WARM model assumes that corrugated cardboard is recycled in a partial open loop, in which 76% of recycled cardboard is used to produce lower-grade paper products such as boxboard, while 24% produces corrugated cardboard [7].

WARM assumes that recycled materials offset the GHG emissions that result from newly produced corrugated cardboard. This difference in GHG emissions from process energy, transportation energy and process non-energy consumption between recycled and virgin material production is represented by a recycled input credit (RIC) [7]. The emissions involved in material management (collection, transportation and processing) for recycling are incorporated into the RIC. As in source reduction, recycling also has GHG emissions benefits from FCS. Detailed discussion of the methodology to calculate RIC and FCS for recycling can be found in WARM documentation [5, 7].

Table 3-2 lists the recycling emission factors for FCS, RIC for process energy, transportation energy and process non-energy, and the net emission factor, represented by RC_{FCS}, $RC_{\mathrm{RIC,PE}}$, $RC_{\mathrm{RIC,trans}}$, $RC_{\mathrm{RIC,PNE}}$, and RC_{tot}, respectively. The net emission from recycling per item returned is

$$E_{\mathrm{RC}} = \Delta m_{\mathrm{new}} RC_{\mathrm{tot}} = \Delta m_{\mathrm{new}} \left(RC_{\mathrm{RIC,PE}} + RC_{\mathrm{RIC,trans}} + RC_{\mathrm{RIC,PNE}} + RC_{\mathrm{FCS}} \right). \quad \text{(Eq. 8)}$$

Table 3-2: WARM Recycling Emission Factors Corrugated Cardboard ($MTCO_2eq$/short ton) [7]

Emission Factors	RIC – Process Energy*, $RC_{\text{RIC,PE}}$	RIC – Transportation Energy*, $RC_{\text{RIC,trans}}$	RIC – Process Non-Energy*, $RC_{\text{RIC,PNE}}$	FCS, RC_{FCS}	Net Emissions, RC_{tot}
Corrugated cardboard	+0.00	-0.05	-0.01	-3.06	-3.12

*Includes emissions from the initial production of corrugated cardboard.

3.6 Landfilling

Landfilling corrugated cardboard results in CO_2 emissions through biological degradation, though this CO_2 is biogenic and therefore not "counted" as an increase in GHG emissions since that CO_2 would have been emitted anyway, had the tree not been harvested and instead decomposed in a forest. However, landfilled material also undergoes anaerobic decomposition, which produces CH_4 as a result of human action (landfilling) and is thus counted as an anthropogenic contribution to GHG emissions.

The GHG emissions from landfilling are partially offset by incomplete decomposition and the capture of CH_4 for energy use. Incomplete decomposition leaves carbon in the landfill indefinitely, representing a removal of carbon from the atmosphere. When a landfill recovers CH_4 and combusts it to generate energy, it replaces fossil fuel combustion. Detailed discussion of the methodology to calculate CH_4 production and energy recovery for landfilling can be found in WARM documentation [5, 7].

Table 3-3 lists the landfilling emission factors for the transportation to landfills, CH_4 production, avoided emissions from energy recovery, landfill carbon storage and the net emission factor, represented by LF_{trans}, LF_{CH4}, LF_{ER}, LF_{CS}, and LF_{tot}, respectively. The net emission from landfilling per item returned is

$$E_{\text{LF}} = \Delta m_{\text{new}} LF_{\text{tot}} = \Delta m_{\text{new}} (LF_{\text{trans}} + LF_{\text{CH4}} + LF_{\text{ER}} + LF_{\text{CS}}). \quad \text{(Eq. 9)}$$

Table 3-3: WARM Landfilling Emission Factors Corrugated Cardboard ($MTCO_2eq$/short ton) [7]

Emission Factors	Transportation to Landfill, LF_{trans}	Landfill CH_4, LF_{CH4}	Avoided CO_2 from Energy Recovery, LF_{ER}	Landfill Carbon Storage, LF_{CS}	Net Emissions, LF_{tot}
Corrugated cardboard	+0.02	+1.05	-0.11	-0.72	+0.23

Note that emission factors for landfill CH_4 are based on nationally averaged landfill gas-capture and energy-recovery rates. Offset emissions from energy recovery are based on non-baseload GHG emissions intensity of U.S. electricity generation.

3.7 Baseline and Alternative Scenarios

The WARM model is a comparative tool that gauges GHG emissions under different waste management scenarios. The U.S. EPA estimates that 89% of corrugated cardboard is recovered for recycling [11]. In the absence of the box-free return model, the baseline scenario would be Δm_{new} mass of corrugated cardboard that must be disposed, of which 89% is recycled and the remaining 11% is assumed to be landfilled. The alternative scenario is source reduction of Δm_{new} mass of corrugated cardboard. The GHG emissions produced from the box-free return model, per item returned, is therefore the difference between the alternative and baseline scenarios, that is

$$\Delta_{\text{GHG}} = E_{\text{SR}} - (0.89E_{\text{RC}} + 0.11E_{\text{LF}}). \quad \text{(Eq. 10)}$$

3.8 Study Limitations

A full Lifecycle Assessment (LCA) is an analytical framework to quantify material inputs, energy inputs and environmental releases from manufacturing, using, transporting and disposing goods or services. The U.S. EPA deems WARM a "streamlined LCA" and developed the model to be transparent and easy to use, the goal being to provide GHG implication information to waste managers and policy makers. WARM is limited to an inventory of GHG emissions, GHG sinks and energy outputs, with waste generation as the reference point for the LCA [5]. As such, this study should not be considered a full LCA.

Additionally, an LCA for the reusable shipping packaging that offsets further corrugated cardboard consumption is not in the scope of this study. Since the reusable packaging has utility for many more cycles (estimated to be tens to hundreds more usage cycles) than corrugated cardboard, the GHG emissions from the reusable packaging are assumed to have a minor to insignificant effect on the conclusions of this study.

4.0 RESULTS AND DISCUSSION

4.1 Material Usage

Table 4-1 lists the calculated new corrugated cardboard consumption per item returned in the case of individual return-by-mail shipments, as calculated using Eqs. 1-2. Each individual return-by-mail item is estimated to result in the consumption of 0.054 pounds (24.5 grams) of new corrugated cardboard.

Table 4-1: New Corrugated Cardboard Consumption for Individual Return-by-Mail Return Shipments

Parameter	Value
Average weight per item (lb)	1
Percentage of returns in new box	40%
Average density of bulk cloth shipment (lb/ft^3)	10.81
Average density of individual cloth shipment (lb/ft^3)	9.73
Single-wall corrugated cardboard grammage (g/m^2)	500
Cardboard required per item (ft^2)	1.32
Average new cardboard usage per item (ft^2)	0.53
Average new cardboard usage per item (lb)	0.054

It should be noted that the results in Table 4-1 assume that only one item is returned per shipment, which is the usual case according to internal Happy Returns data. In the infrequent case of a return-by-mail shipment containing multiple items, there are cardboard consumption reductions that can be realized by the consumer, since Eq. 1 is an exponential function to the 2/3 power.

Figure 4-1 shows the average weight of new cardboard that would be used in a return-by-mail shipment when increasing the number of items in the shipment. It would require the exceptional case of a consumer sending a return-by-mail shipment with 10 items in the same box for the weight of new cardboard, and therefore the GHG emissions from packaging, to be roughly half that compared to 10 individual return-by-mail shipments containing a single item each.

Figure 4-1: Mass of New Cardboard Consumed in Return-by-Mail Shipments as a Function of Items in Shipment

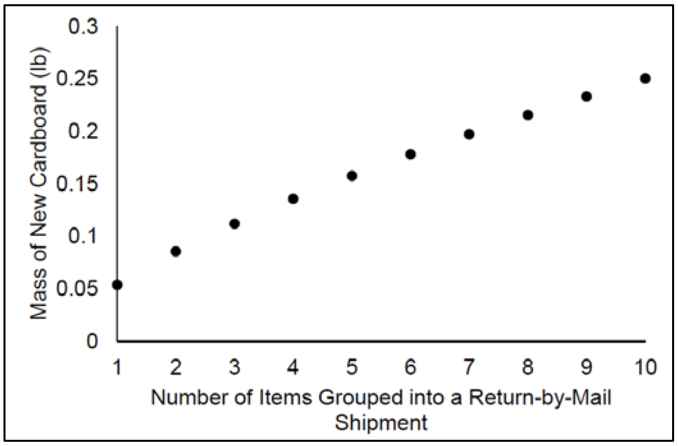

Table 4-2 lists the calculated new corrugated cardboard consumption per item returned in the case of aggregated box-free return shipments, as calculated using Eqs. 3-5. Each item returned through this route is estimated to result in the consumption of 0.015 pounds (6.8 grams) of new corrugated cardboard.

Table 4-2: New Corrugated Cardboard Consumption for Aggregated, Box-Free Return Shipments

Parameter	Value
Average weight per item (lb)	1
Percentage of returns in Gaylord box	25%
Average density of bulk cloth shipment (lb/ft^3)	10.81
Triple-Wall corrugated cardboard grammage (g/m^2)	1758
Gaylord box [48 in x 40 in x 36 in] volume (ft^3)	40
Gaylord box [48 in x 40 in x 36 in] surface area (ft^2)	70.67
Gaylord box capacity (items)	432.40
Cardboard area required per item (ft^2)	0.16
Average new cardboard usage per item (ft^2)	0.04
Average new cardboard usage per item (lb)	0.015

Table 4-3 quantifies the final net new corrugated cardboard reduction per item returned through the box-free return model compared with individual return-by-mail shipments, as calculated using Eq. 6. The new cardboard savings is estimated to be 0.039 pounds (17.7 grams) per item, for a reduction of 72.7% by mass and 92.2% by area.

Table 4-3: Net New Corrugated Cardboard Consumption Reduction for Items Returned Through the Box-Free Return Model Compared with Individual Return-by-Mail Shipments

Parameter	Value
Average new cardboard reduction per item (ft^2)	0.49
Average new cardboard reduction per item (lb)	0.039
New cardboard area % reduction	92.2%
New cardboard mass % reduction	72.7%

4.2 Source Reduction (Alternative Scenario)

Using the emission factors in Table 3-1 and Eq. 7, GHG emissions from source reduction of corrugated cardboard (box-free return model) was calculated per item, as shown in Table 4-4.

Table 4-4: Per-Item Source Reduction Emissions for Current Mix of Corrugated Cardboard Under the Box-Free Return Model

Emission Process/Stage	Emission Factor ($MTCO_2eq$/short ton)	Emission ($MTCO_2eq$/item)	Emission (lb CO_2eq/item)
Current mix RMAM	-0.87	-1.71E-05	-0.04
Current mix FCS	-4.73	-9.28E-05	-0.20
Current mix net	-5.6	-1.10E-04	-0.24

Source reduction resulting from the box-free return model can generate GHG savings of about a quarter-pound of CO_2eq per item. It is clear that reduced tree harvesting and increased FCS (~85% of GHG reductions) are what drive the GHG emissions savings from source reduction.

4.3 Recycling and Landfilling (Baseline Scenario)

GHG emissions from recycling were calculated using the emission factors in Table 3-2 and Eq. 8, while those for landfilling were calculated using Table 3-3 and Eq. 9. The recycling and landfilling emissions for new corrugated cardboard that would be used in the absence of the box-free return model are shown in Table 4-5 and Table 4-6, respectively.

Table 4-5: Recycling Emissions for New Corrugated Cardboard Used for Individual Return-by-Mail Shipments

Recycling Emission Process/Stage	Recycling Emission Factor ($MTCO_2eq$/short ton)	Recycling Emission ($MTCO_2eq$/item)	Recycling Emission (lb CO_2eq/item)
RIC process energy	0	0.00E+00	0.00E+00
RIC transportation energy	-0.05	-9.80E-07	-2.16E-03
RIC process Non-energy	-0.01	-1.96E-07	-4.32E-04
FCS	-3.06	-6.00E-05	-1.32E-01
Net	-3.12	-6.12E-05	-1.35E-01

Table 4-6: Landfilling Emissions for New Corrugated Cardboard Used for Individual Return-by-Mail Shipments

Landfilling Emission Process/Stage	Landfilling Emission Factor ($MTCO_2eq$/short ton)	Landfilling Emission ($MTCO_2eq$/item)	Landfilling Emission (lb CO_2eq/item)
Transportation energy	0.02	3.92E-07	8.65E-04
Landfill methane	1.05	2.06E-05	4.54E-02
Energy recovery	-0.11	-2.16E-06	-4.76E-03
Landfill carbon storage	-0.72	-1.41E-05	-3.11E-02
Net	0.23	4.51E-06	9.94E-03

Landfilling has a variety of GHG sources and sinks, but the net result is that landfilling corrugated cardboard emits GHG. CH_4 production dominates landfill GHG sources (at ~98% of GHG sources), while sinks are dominated by landfill carbon storage (~85% of GHG sinks). Net landfilling GHG emissions are roughly 10 times less than the GHG reductions realized through recycling the same amount of corrugated cardboard.

Similar to source reduction, the savings achieved from recycling GHG emissions are largely in FCS (~98% of GHG reductions). Comparing Table 4-5 to Table 4-4, it is evident that while recycling corrugated cardboard provides a substantial decrease in GHG, source reduction can achieve even greater GHG elimination, by a factor of ~2. These results suggest that source reduction is by far the most effective means to cutting GHG emissions associated with shipment packaging and supports the environmental benefits of shipping aggregation and the box-free return model.

4.4 Net GHG Effects of the Box-Free Return Model

The difference between the alternative scenario (box-free return model) and the baseline scenario (recycling and landfilling of new cardboard packaging used for individual return-by-mail shipments) represents the net reduction in GHG emissions using the alternative scenario (Eq. 10). Table 4-7 shows the net effects to GHG under the alternative scenario in three ways: 1) the limit in which all new cardboard would have been recycled, 2) the limit in which all new cardboard would have been landfilled, and 3) a more reasonable scenario in which 89% of the new cardboard would have been recycled and the remaining 11% would have been landfilled.

Table 4-7: Net GHG Emissions Δ_{GHG} for New Corrugated Cardboard (lb CO_2eq)

Scenario Emissions (lb CO_2eq/item)	1: 100% Recycling Rate, 0% Landfilling Rate	2: 0% Recycling Rate, 100% Landfilling Rate	3: 89% Recycling Rate, 11% Landfilling Rate
Source reduction	-0.242	-0.242	-0.242
Recycling	-0.135	0.000	-0.120
Landfilling	0.000	0.010	0.001
Estimated GHG emissions reductions through box-free return model	-0.107	-0.252	-0.123

In the best baseline scenario of 100% recycling rates, the net GHG reduction from the box-free return model is more than one-tenth of a pound of CO_2eq per item returned. Conversely, in the worst baseline scenario of 100% landfilling rates, the net GHG reductions from the box-free return model would be more than one-quarter of a pound of CO_2eq per item returned.

Since the actual corrugated cardboard recycling rate is about 89%, the net GHG reductions from the most probable 89%-11% split of cardboard recycling and landfilling is closer to the limit in which all cardboard is recycled. It is estimated, then, that on average, the box-free return model can realize about 0.12 pounds (54 grams) of avoided CO_2eq emissions per item returned.

Internal data from Happy Returns indicates that the number of returns for an individual retailer ranges from 10,000 to 1 million items per year. An individual retailer participating in this box-free return model could then realize emission reductions of 1,200 to 120,000 pounds CO_2eq (about 0.5 to 50 $MTCO_2$eq) per year from packaging reductions alone.

5.0 CONCLUSIONS

A waste management GHG emissions model (WARM) developed by the U.S. EPA was employed to quantify the GHG emissions reductions that could be realized by decreasing the amount of new corrugated cardboard used in individual e-commerce retail return shipments. A returns shipment aggregation service such as Happy Returns inherently allows for the reduction of corrugated cardboard through a box-free return model. Using internal data on return shipments, the GHG reductions from the box-free return model were calculated. The result was a clear decline in GHG emissions associated with packaging disposal. The amount of GHG emitted per returned item would be reduced by 0.12 pounds (54 grams) CO_2eq when using the box-free return model, compared with recycling and/or landfilling new corrugated cardboard packaging associated with individual return-by-mail shipments.

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