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CARBON FOOTPRINTING

Life cycle carbon footprint of the National Geographic magazine

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Abstract
Purpose Climate change is an urgent and serious global problem. Life cycle assessment methods may be used to evaluate the life cycle carbon footprint of a product, such as the National Geographic magazine. The results of the study provide the publisher and material suppliers with information to reduce life cycle greenhouse gas (GHG) emissions. The study also informs consumers of the GHG emissions associated with the product. The purpose of this study was to document the life cycle carbon footprint of the National Geographic magazine.
Methods Currently, there is no international standard for conducting a product life cycle carbon footprint. Both the International Standards Organization (ISO) and the World Resources Institute's Greenhouse Gas Protocol are working to develop standards. The study followed the ISO standards for life cycle assessment (ISO 14040:2006 and ISO 14044:2006). The *Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard* also provided guidance.
Results The study showed that the life cycle of the National Geographic magazine produces about 0.82 kg of carbon dioxide equivalents per life cycle of the average magazine. The amount of GHG emissions per life cycle of each magazine produced is about the same amount of GHG emissions produced by driving an automobile (8.5 km/liter gasoline) for about 3 km.
Discussion High quality, geographically and temporally representative data for the study were provided by National Geographic, Verso Paper, and Quad Graphics. These data are specific to the magazine life cycle and account for about 88% of the total energy results and about 75% of the total GHG emissions for the entire life cycle of the magazine. The study includes extraction of raw materials from the earth, processing of raw materials, fuels, intermediate products, transportation steps, manufacture of paper, printing, distribution of the magazine, and final disposition.
Conclusions The results indicate that opportunities for improving the carbon footprint of the magazine are more likely to be found within the manufacturing and printing of the paper. These two steps account for the majority of the greenhouse gas emissions. Including recycled fiber into magazine paper did not improve the carbon footprint of the magazine. Incorporation of groundwood did impact end-of-life emissions from disposal into landfills.

Keywords Carbon footprint · Climate change · Global warming potential · Greenhouse gas emissions · Life cycle · Magazines

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1 Introduction

"Carbon footprint" is a term that is commonly used to describe the amount of greenhouse gas (GHG) emissions caused by a particular activity or entity. To calculate a carbon footprint, emission quantities of individual gases (GHG) are converted to the measurement of carbon dioxide equivalents (CO_2 equivalents) using the Intergovernmental Panel on Climate Change (IPCC) 100-year Global Warming Potential (GWP) factors. This allows the potential effect on climate change from different activities to be evaluated on a common basis. In this study, the GHG emissions from each activity within the product system boundary are converted to CO_2 equivalents and summed to calculate the carbon footprint or global warming potential of the life cycle of the National Geographic magazine.

Product life cycle carbon footprints or greenhouse gas (GHG) inventories are increasingly being used to convey to customers and the public the potential contribution of a product to climate change, a global concern. Additionally, companies are using results of these studies to make operating, manufacturing, and supply chain decisions, as well as decisions for purchasing renewable energy certificates or carbon offsets. The results presented in this study quantify the total energy requirements, energy sources, and greenhouse gas emissions from combustion of fuel and emissions from other processes resulting from the life cycle of National Geographic magazine. It is recognized by the author and sponsors of the study that a life cycle GHG inventory does not fully evaluate all environmental consequences of a product system. However, the study does present information related to a critical environmental topic, climate change. Readers are cautioned that the results for this study are specific to the National Geographic magazine. There is no intent to make observations, claims, or present information about other paper product systems or magazines.

2 Methods

2.1 Protocols and guidance

There are currently no US or international standards for conducting product life cycle greenhouse gas inventories. However, both the International Standards Organization (ISO) and the World Resources Institute's Greenhouse Gas Protocol are currently working to develop standards. This study follows guidance in the ISO Standards for Life Cycle Assessment (ISO 2006) and also takes direction from the EPA Climate Leaders program (USEPA 2009) and the WRI GHG Protocol Corporate Accounting and Reporting Standard (WBCSD/WRI 2001).

For consistency with the United Nations Framework Convention on Climate Change (UNFCCC) and the United States EPA Climate Leaders Protocol, the study uses 100 year GWP factors from the IPCC Second Assessment Report published in 1996 (IPCC 1996).

Franklin Associates proprietary LCI models and data were used with permission to perform this study.

2.2 Scope and boundaries

The reference flow for this study is on a mass basis (1,000 kg) of National Geographic magazines produced and delivered to consumers. Results are first provided on a mass basis to allow users of the report to easily calculate results for different quantities of magazines and to also allow the National Geographic Society to estimate changes in results if the magazine paper basis weight is changed. The functional unit for the study is one magazine. An average magazine in 2008 weighed approximately 349 g. GWP results are also calculated for one million magazines and the 2008 annual production of magazines.

Weighted averages for magazine weights, transport distances, and transport modes for the calendar year of 2008 are used to model the life cycle of an "average" magazine. Energy use for building occupancy, pulp and paper mill, and printing data are for the calendar year of 2007. Coatings data and data for manufacture of recycled pulp are for the calendar year of 2006. Data from the supplier of the coated magazine paper and the printer are specific to the National Geographic magazine. The study provides no information about the carbon footprint of other publications. Figure 1 is a simplified illustration of the boundaries and material flows for the system.

To the extent possible, this study used specific data for the National Geographic magazine life cycle. Data from the paper supplier is specific to the paper used for the magazine. Wood transport distances, life cycle GHG emissions for many of the coatings used on the paper, data from the recycled fiber supplier for the paper are all specific to the paper used for the National Geographic magazine. Likewise, the printer of the magazine provided data specifically for this study. National Geographic building operations were allocated on the basis of area used for publishing the magazine. Travel by National Geographic staff relative to publishing and advertising the magazine were included.

The use of 0%, 5%, and 10% recycled fiber content in the coated magazine paper is evaluated in this study. These are realistic options for adding recycled fiber content for the magazine at this time. Recycled fiber potentially affects machine efficiency at the paper mill and the quality of the printed magazine paper. Recycled fiber was modeled using the "cut-off" method. The unit processes for recycled fiber began with collection of postconsumer paper. No burdens from manufacturing of the original virgin paper were included. Open-loop recycling (allocating burdens between the virgin and recycled products) is an alternative allocation method. A sensitivity analysis was not performed on the allocation method for recycled fiber content because recycling did not significantly affect the study results for energy or GHG emissions when comparing 0% recycled fiber content to 10% recycled fiber content. The coated magazine paper contained about 5% postconsumer recycled fiber content in 2008. If the recycled fiber content had significantly contributed to the results, a sensitivity analysis to evaluate alternative methods of allocation would have been performed.

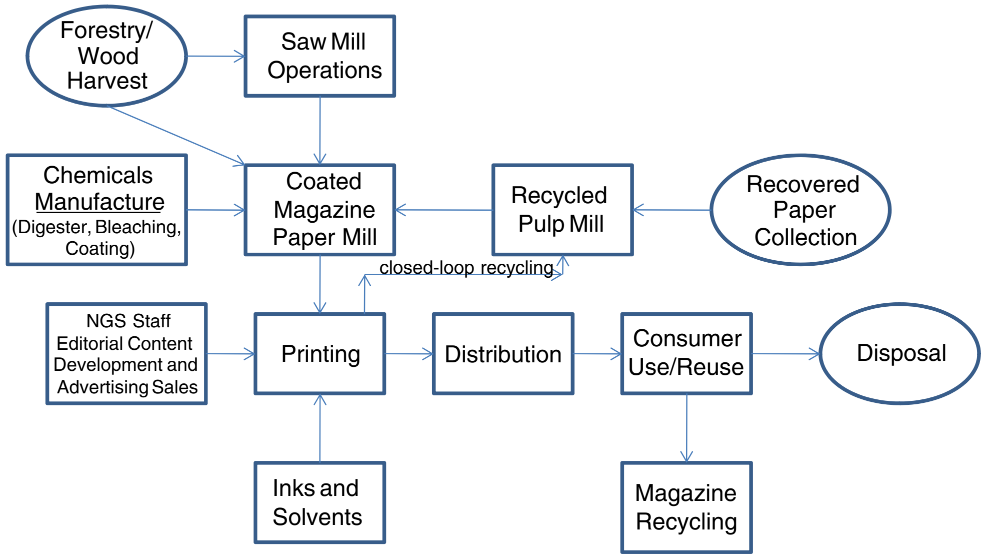

Fig. 1 System boundaries for life cycle carbon footprint of the National Geographic magazine

For recycling of postconsumer magazines, the same "cut-off" method for open-loop recycling is used. Recycled magazines leave the system and become a raw material for another product system. For the magazines that are recycled at end of life, all initial production burdens for the magazines are allocated to the magazine, while the product system using the magazines as raw material is allocated the burdens for collection, reprocessing, and ultimate disposal of the material. A sensitivity analysis for this method of allocation and open-loop recycling allocation is presented in the report.

Based on National Geographic Society survey data, it was calculated that 60% of the magazines are permanently archived by consumers. The remaining magazines were assumed to be disposed to the municipal solid waste stream. In the USA approximately 80% of MSW is landfilled, and 20% is incinerated with energy recovery (USEPA 2008).

2.3 Uncertainty of results

Based on the uncertainty in the energy data, energy differences between systems are not considered meaningful unless the percent difference between systems is greater than 10% (percent difference between systems is defined as the difference between energy totals divided by the average of the two system totals). This minimum percent difference criterion was developed based on the experience and professional judgment of the analysts.

The GHG emissions reported in this study include those associated with production of materials and production and combustion of fuels. The emissions tables present emission quantities based upon the best data available. However, in the many unit processes included in the system models, some emissions data have been reported from industrial sources, some are estimated from EPA emission factors, and some have been calculated based on reaction chemistry or other information. This means that there are significant uncertainties with regards to the application of the data. Because of these uncertainties, the difference in two systems' emissions of a given substance is not considered meaningful unless the percent difference exceeds 25% (percent difference is defined as the difference between two system totals divided by their average). This minimum percent difference criterion was developed based on the experience and professional judgment of the analysts.

Franklin Associates has been using these uncertainty estimates for more than 20 years, and Harmony Environmental has adopted the same estimate based on professional experience of the analysts with numerous life cycle assessment inventories for many different types of products.

2.4 Data quality

ISO standard 14044:2006 states that "Data quality requirements shall be specified to enable the goal and scope of the LCA to be met." Data quality requirements listed are time-related coverage, geographical coverage, technology coverage, and more.

The data quality goal for this study was to use data that most accurately represent the specific processes and supply chain for producing and delivering the National Geographic magazine to customers. Data from the paper supplier, printer, and National Geographic Society were collected directly for this study. These data include detailed information on the pulp and paper mill operations, printing operations, development of editorial content, and NGS advertising activities associated with the magazine. Engineers and company representatives reviewed and assisted in allocating resources, energy and emissions correctly to the magazine. The United States Postal Service (USPS) provided detailed spreadsheets to assist with the effort of determining the transportation fuel use and emissions for delivering the magazine.

2.4.1 Time-related coverage

Production quantities, magazine weights, and transportation distances and modes received from NGS and printer are for the calendar year, 2008. Building occupancy data for content development and advertising of the National Geographic magazine are for the calendar year of 2007. Data collected from the pulp and paper mill and printer are annual data for the calendar year, 2007. Fuel-related emission factors in the Franklin database were reviewed and updated in 2008 by Franklin Associates staff. Refinery, chemicals, wood harvesting, and sawmill data are from the NREL LCI database (NREL 2008). USPS transportation data for magazines are from a peer reviewed LCI report dated June 2008 (USPS 2008). End-of-life management for magazines delivered in the USA is from the November 2008 EPA MSW study (USEPA 2008). Additional research was conducted to estimate end-of-life management for magazines delivered outside of the USA [Achankeng (2003); Australian Bureau of Statistics (2006); Bontoux (1999); Environment Canada (2009); Estevez (2003); European Recovered Paper Council (2007); EuroStat (Accessed April 10 2008); Hands On TV (Accessed 15 March 2009); Hincapie (2007); India Together (2002); Monteir (2008); Ministry for the Environment (2005); Paper Recycling Association (Accessed 8 April 2009); Paper Recycling Association of South Africa (Accessed 8 April 2009); Paper Recycling Promotion Center (Accessed 8 April 2009); Statistics Canada (2006)]. Data for LDPE plastic film and Kraft paper/paperboard are from a published LCI report of packaging materials for Oregon Department of Environmental Quality conducted by Franklin Associates in 2004 (ORDEQ 2004).

2.4.2 Geographic coverage

Manufacturing data used for this study are US data, which is appropriate because the manufacture of the paper, magazine, and nearly all chemicals and packaging materials in the life cycle occurs in the USA. The National Geographic Magazine is shipped to several countries. Transportation energy to ship the magazines to other countries is estimated based on transportation modes and distances used to transport the magazines from the USA to destination countries, using fuel emission factors in the LCI database, which are based on the production and combustion of fuels in the USA. Likewise, NGS staff transportation and accommodations for content development and advertising sales is global, and distances are based on actual company travel records. End-of-life management for magazines in other countries is estimated based on research of disposal practices in other countries. Fuel use for transport of disposed magazines and landfill operations is based on US data.

2.4.3 Technology coverage

Data in the LCI database reflect typical technology at the time the data were collected. Technology coverage is not a major issue for this study. The processes that contribute the most to the results are pulp and paper manufacture and printing. These are the suppliers for the magazine; therefore, the appropriate technologies are covered.

Data quality is summarized in Table 1. The highest quality data (A) accounts for about 88% of the total energy results and about 75% of the total GHG emissions (carbon dioxide equivalents).

2.5 Peer review

The study was peer reviewed by Mary Ann Curran, USEPA and by Reid Miner and Caroline Gaudreault, NCASI. Peer review comments were addressed by revising the report or explaining why the report was not revised.

3 Results

3.1 Energy results

Energy results, as well as GHG emissions, are reported because, for most products, the combustion of fuel is the major contributor to GHG emissions for the life cycle of the product. An evaluation of energy use is helpful in understanding the GWP results. Total energy results are shown in Table 2 by energy categories of process, transport, and energy of material resource for the life cycle system with 5% recycled fiber content in the magazine paper. Process energy is the sum of all energy used in manufacturing each material used to make the final product, including acquiring raw materials, manufacturing coatings, paper, recycled fiber, printing, and publication operations. Transport energy is the sum of the energy needed to transport raw materials, intermediate materials, and magazines to their final destination. Energy of material resource is energy embodied in materials that are made from petroleum-based energy resources. The total energy results as shown in Fig. 2 by fossil and non-fossil fuels illustrate that there is less than 10% difference in total energy results for the magazines made with 0%, 5%, or 10% recycled fiber content.

Table 2 shows total energy measured in megajoules per tonne by major process steps. Cradle-to-gate energy for coated magazine paper is about 79% of the total energy.

Table 1 Data quality summary

LCI step	Source of data	Data quality
Coated magazine paper	Actual paper supplier to NGS	A
Recycled pulp for magazine paper	Actual pulp supplier to paper supplier	A
Printing	Actual magazine printer	A
Chemicals, coatings, ancillary materials	Franklin Associates LCI database	B–C
Magazine delivery by USPS	Peer reviewed LCI study—detailed tables	B
Magazine delivery by other carriers	Estimates based on actual distances	C
NGS operations and travel	2008 utility and transportation records	A
Pallets and packaging	Public LCI data sources	B
Disposal practices in USA	EPA MSW 2007 Facts and Figures	B
Disposal practices in other countries	Literature search for this study	D
Landfill operations in USA	Estimates based on research triangle Institute's municipal solid waste Decision support tool	C
Landfill emissions from decomposition	Best estimates available based on most recent landfill research results	D

A = appropriate and best possible data, reviewed for accuracy, B = typical LCI data sets, reviewed for appropriateness to study, C = estimates made using limited, but high quality data, D = estimates made using data known to be uncertain

Source: Harmony Environmental, LLC

This is the summed energy for forestry operations and harvesting trees through producing and delivering coated magazine paper to the printer. Printing operations, solvents manufacture, and transportation by the printer make up another 17% of the total energy. The remaining 4% is due to manufacture of pallets and plastic packaging, transport of magazines by the USPS and other carriers, NGS operations (space conditioning and lights for buildings and travel attributed to content development and advertising), collection of magazines as part of municipal solid waste and landfill operations, and a combustion credit of about −1% of the total. The energy credit is for waste-to-energy combustion of a portion of the magazines and packaging materials that end up in municipal solid waste (Domalski and Milne 1987; Fire 1991).

Figure 2 shows total energy by fossil and non-fossil fuel. Fossil fuels are natural gas, petroleum, and coal used for direct combustion as process and transportation fuels and to produce electricity. Wood-derived energy is a non-fossil source used in pulp and paper mills when wood wastes are used for fuel. Other non-fossil sources are hydropower, nuclear, and other (geothermal, wind, etc.) energy sources used to produce purchased electricity. For each scenario, fossil fuels account for about 53% of the total energy use for the life cycle of the magazines.

3.2 GWP results

Life cycle GHG emissions are converted to GWP and reported in units of kilograms of carbon dioxide equivalents (CO_2-equiv) per 1,000 kg of magazines. Total GWP includes GHG emissions from

– Combustion of fuels directly consumed in process and transportation steps
– Combustion of fuels and transmission losses to produce and deliver purchased electricity
– Precombustion of GHG emissions (the GHG emissions from extraction and processing of fuels used for process energy and transportation energy)
– GHG emissions from unit processes that emit non-fuel-related GHGs

Table 2 Energy results by energy category (MJ/t)

Life cycle steps	Process energy	Transport energy	Energy of material resource	Total energy	Percent of total
Using 5% recycled content paper					
Coated magazine paper	43,240	1,778	6	45,024	79%
Printing	6,324	3,336	129	9,788	17%
Transport by USPS and others	229	611	0	840	1%
NGS operations and travel	341	45	0	386	1%
Pallets and packaging	809	62	779	1,651	3%
Disposal and landfill operations	0	268	0	268	0%
Combustion energy credit	−723			−723	−1%
Total	50,560	6,145	914	57,619	100%

Source: Harmony Environmental

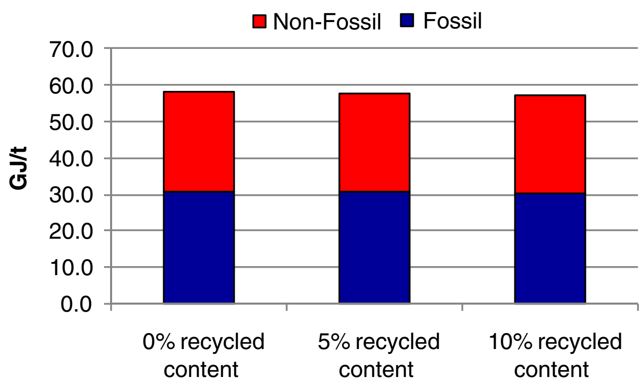

Fig. 2 Fossil and non-fossil energy

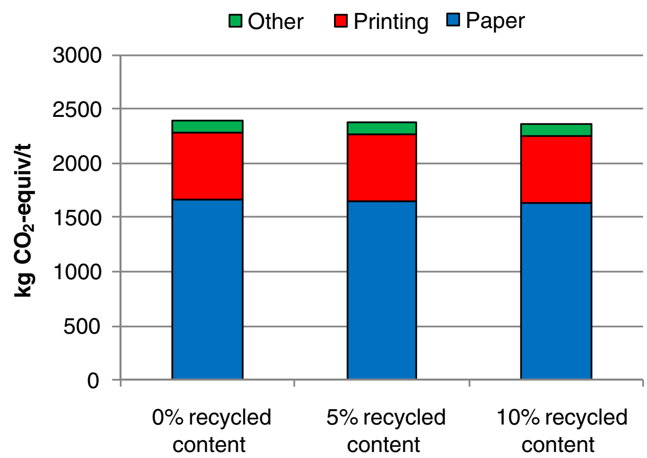

Fig. 3 Total GWP by process

GWP is reported in the units of CO_2-equiv for magazines made with paper containing 0%, 5%, and 10% recycled fiber content. Total GWP for magazines made with paper containing 0%, 5%, and 10% recycled fiber content is 2,384, 2,370, and 2,357 kg CO_2-equiv, respectively. Differences in total GWP for the magazines made with paper containing 0%, 5%, and 10% recycled fiber content are not significant. An issue not addressed in this study because comparisons to other products are not made is that using recycled fiber in coated magazine paper requires more cleaning and possibly more transportation than use of recycled fiber in lower end paper products. In a market climate where recycled fiber is limited, it may be of more global climate benefit to reserve recycled fiber for products that require less energy for processing of the recycled fiber for reuse.

In Table 3, total GWP in kg CO_2-equiv per tonne of magazines is shown by the categories of process, fuel, and self-reported for the life cycle system with 5% recycled fiber content in the magazine paper. Process emissions are emissions directly emitted from a manufacturing process, such as carbon dioxide emissions from manufacturing lime from calcium carbonate. Fuel emissions are emissions from the preparation and combustion of fuel. Self-reported emissions are cradle-to-gate GHG emissions reported by suppliers of coatings or GHG emissions from travel calculators. In these cases, the author was not able to review the basis of calculations. Fuel-related emissions make up 90% total GWP. Self-reported emissions make up about 9% of total GWP. Process emissions are a little more than 1% of total GWP. Sixty-four percent of the fuel-related GWP is attributable to the cradle-to-gate GHG emissions for manufacture of coated magazine paper.

Total GWP for 1,000 kg of magazines is shown by major process steps in Fig. 3. Cradle-to-gate GWP for coated magazine paper is about 70% of the total GWP for each scenario. This is the summed GHG emissions (converted to carbon dioxide equivalents) for forestry operations and harvesting trees through producing and delivering coated magazine paper to the printer. Printing operations, solvent manufacture for inks, and transportation by the printer account for about 26% of the total GWP. The remaining 4% of the total GWP is from transport of magazines by USPS and other carriers, manufacture of pallets and plastic packaging, NGS operations (space conditioning and lights for buildings and travel attributed to content development and advertising), municipal solid waste collection and landfill equipment, and an end-of-life management credit of about −2% of the total GWP. The credit for end-of-life management is due to the sequestering of carbon by

Table 3 Global warming potential by category (kg CO_2-equiv/t)

Life cycle steps	Process	Fuel	Self-reported	Total
Using 5% recycled content paper				
Coated Magazine Paper	73.4	1,378	198	1,650
Printing	0.22	614	0	614
Transport by USPS and others	0	58.2	0	58.2
NGS operations and Travel	7.25	23.8	3.39	34.4
Pallets and packaging	5.99	46.5	0	52.5
Disposal and landfill operations fuels	0	18.9	0	18.9
End-of-life management[a]	-57.6			−57.6
Total	29.2	2,140	201	2,370

[a] Emissions from WTE and landfill decomposition/sequestration

Source: Harmony Environmental, LLC

disposal of coated magazine paper into landfills (Barlaz 1997; USEPA accessed 2008; Ximenesa et al. 2008). A portion of the coated magazine paper is non-degradable in landfills. When magazines are landfilled, a portion of the biogenic carbon in the magazine is removed from the natural carbon cycle of wood used as a raw material. The natural carbon cycle of the wood requires replacement of the sequestered carbon. The sequestration process is modeled as a sink for fossil carbon or a credit against the sum of fossil carbon dioxide emissions for the system. When measured as potential GWP, more carbon is sequestered than is released as methane gas from the degradable portion of the magazines. End-of-life management is discussed in more detail in Sections 2.2 and 3.3.

3.3 Sensitivity analyses

Sensitivity analyses were performed for the number of magazines recycled and for the recycling method for postconsumer magazines. The sensitivity analysis for the number of magazines recycled assumed no archiving of magazines by consumers versus 60% of magazines archived as modeled for the study. Total GHG emissions measured as carbon dioxide equivalents decrease by about 2% if the sensitivity analysis scenario is used instead of the best estimate for end-of-life waste management. Coated magazine paper in landfills sequesters more carbon, measured as carbon dioxide equivalents, than is released by the degradation of the magazine paper (Barlaz et al. 1997). This is because the magazine paper contains a significant portion of groundwood pulp. Groundwood contains lignin, which prevents degradation of the wood pulp in landfills. The sensitivity analysis for open-loop recycling of postconsumer magazines used the "number of subsequent uses" method for open-loop recycling and assumed one subsequent use as a recycled product. The virgin product (magazine) and recycled product shared equally on a mass basis the total system burdens of manufacturing the virgin and recycled paper. These sensitivity analyses indicate that the GWP results of the study would not be significantly different from the base case study results. The combined effects of both sensitivity analyses of no archiving and the open-loop "number of subsequent uses" method resulted in a total GHG emissions measured as carbon dioxide equivalents decrease by about 7%. These differences are within the uncertainty boundaries for results of the study.

Another sensitivity analysis was performed on the source of electric power for the coated paper mill. The coated magazine paper supplier to NGS purchases electricity from a power company in Canada. The average mix of fuels used to produce electricity for the Canadian power grid includes nearly 60% hydroelectric power, which reduces the GHG emissions associated with purchased electricity for the paper mill compared to purchasing electricity from the US electricity grid. As a sensitivity analysis, the fuel mix for purchased electricity was revised to reflect the average mix of fuels used by the NPCC New England subregion electricity grid as reported by the Emissions & Generation Resource Integrated Database (eGRID) 2007. The paper mill is located in this region. eGRID reports that more than 60% fossil fuel is used to produce electricity for this subregion. The sensitivity analysis showed an increase in total energy use of about 4% if purchased electricity were obtained from the NPCC New England subregion electricity grid instead of the Canadian electricity grid. The total GHG emissions measured as carbon dioxide equivalents also increased by about 6–7% if purchased electricity were obtained from the NPCC New England subregion electricity grid instead of the Canadian electricity grid. These differences are within the uncertainty boundaries for results of the study.

4 Discussion

One surprising result of the study is the contribution of the printing step to the carbon footprint of the product. Printing

Table 4 Global warming potential for different quantities of magazines (kg CO_2-equiv)

Life cycle steps	One magazine	One million magazines	Annual production (2008)
Using 5% recycled content paper			
Coated magazine paper	0.57	574,106	44,862,222
Printing	0.21	213,728	16,701,316
Transport by USPS and others	0.02	20,253	1,582,588
NGS operations and travel	0.01	11,981	936,249
Pallets and packaging	0.02	18,258	1,426,746
Disposal and landfill operations fuels	0.01	6,593	515,205
End-of-life management[a]	−0.02	−20,061	−1,567,622
Total	0.82	824,859	64,456,704

[a] Emissions from WTE and landfill decomposition/sequestration

Source: Harmony Environmental, LLC

accounts for about 26% of the total GHG emissions measured in carbon dioxide equivalents. The printing step includes cradle-to-gate GHG emissions for the manufacture of solvents for inks, gravure printing of the magazine pages allocated on the basis of the number of pages printed, and transportation by the printer to magazine drop off sites. Even so, this percentage contribution is larger than reported by other studies of printed materials. Review of the data and calculations indicates that the results are accurate. The higher percentage contribution from printing to the carbon footprint is likely due in part to the fact that the paper mill purchases hydroelectric power from a power plant in Canada rather than fossil fuel-generated electricity. Other studies may also have separated out the GHG emissions for transportation by the printer into a different category.

Another interesting result is the small benefit of including 5% or 10% recycled paper content in the magazine paper. The study attempted to give the maximum benefit for using recycled fiber content, yet the value to the carbon footprint of the magazine is insignificant. There is much debate about the validity of giving a credit for removing postconsumer paper from the waste disposal stream. Debate centers on the market demand for recycled pulp and paper products. Adding recycled content to a product may simply keep another company from using more recycled content and not actually remove additional quantities of postconsumer paper from the total waste stream going to landfills. In this study the evaluation of using 5% or 10% recycled content is a calculation of the *upper limit* of reduction of greenhouse gas emissions that *may* occur because the recovered paper used in the coated magazine product is recycled instead of disposed. The information for estimating emissions from landfills is limited and the uncertainty is large. The actual GHG emissions reduction for using recycled pulp in coated magazine paper is thought to be somewhere between zero and the calculated upper limit shown as a credit in this report. The purpose of presenting the upper limit is to assist the decision-maker in evaluating the potential benefit of using recycled pulp for this particular product. Other factors, such as energy efficiency, machine downtime, and quality of product, are also important considerations when making decisions about recycled content for any given product.

5 Conclusions

As shown in Table 4, the life cycle of the National Geographic magazine produces about 0.82 kg of carbon dioxide equivalents per average magazine, 825,000 kg of carbon dioxide equivalents per one million magazines and 64.5 million kilograms of carbon dioxide equivalents for the 2008 annual production. The amount of GHG emissions per each magazine produced is about the same amount of GHG emissions produced by driving an automobile (20 miles per gallon or 8.5 km per liter gasoline) for about 3 km.

Total GWP results have an estimated uncertainty of plus or minus 25%. This means that it is likely that other LCI practitioners, using the same data sources to do the same study, would find that the life cycle of the National Geographic magazine produces between 0.6 and 1.0 kg of carbon dioxide equivalents per magazine.

The results indicate that opportunities for improving the carbon footprint of the magazine are more likely to be found within the manufacturing and printing of the paper. These two steps account for the majority of the greenhouse gas emissions. A detailed evaluation of the paper manufacturing and printing processes and implementation of energy efficiency improvements may be able to lower the carbon footprint of the magazine. Furthermore, including recycled fiber into magazine paper did not improve the carbon footprint of the magazine. However, incorporation of groundwood did impact end-of-life emissions from disposal into landfills.

For the consumer, knowing the carbon footprint of an average magazine gives each individual purchaser the opportunity to offset the purchase of the magazine by curtailing other personal activities that generate GHG emissions. In this way, consumers may become an effective part of the effort to lower global GHG emissions.

Copies of the full report may be obtained by contacting the author at tboguski@harmonyenviro.com.

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