The Development of a Standard Tool to Predict the Environmental Impact of Footwear

A Group Project in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management from the Donald Bren School of Environmental Science and Management at the University of California, Santa Barbara

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Prepared May 2009

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1. Abstract

In response to consumer demand, footwear manufacturing has increased dramatically in recent decades, increasing the industry's impact on the natural environment. Life cycle assessment (LCA) methods can be used to quantify the environmental impacts of footwear manufacturing process. Using state-of-the-art software such as GaBi4 and I-Report, this project will develop a calculator which can be used by footwear designers at Deckers Outdoor Corporation in predicting the environmental impact of manufacturing shoes using different designs. The environmental impacts assessed using GaBi LCA software will ultimately be translated to simplified environmental scores to better highlight the impacts to the client. If feasible, the calculator will incorporate the cost of each design as well.

2. Executive Summary

Deckers Outdoors Corporation aims to be an industry leader in reducing the environmental impact of the products in their Simple Shoes brand. Simple is a line of shoes focused on "100% sustainability" of their products (www.simpleshoes.com, 2009). They use materials with less environmental impact than conventional materials, such as organic cotton, hemp, and water-based adhesives. Also, Simple utilizes less energy and material intensive manufacturing processes such as cold-cementing shoes. However, the impact of alternative materials can often be anecdotal and rigorous analyses may show that, in reality, the changes have little to no benefits. Therefore, a recent Bren School LCA project verified that Simple's alternative materials are indeed more environmentally benign than conventional materials (Albers et al., 2008).

This year Deckers approached the Bren School again for assistance, this time to predict the environmental impact of a shoe during the design phase. Therefore, the goal of this project is to create a model that can be used to evaluate the environmental impact of shoes prior to production. Traditional LCAs are typically conducted to assess environmental impacts after the product is made. However, this new model will be intended for use during the design phase, *prior* to manufacture. Using expertise and resources from the Bren School and Deckers, this project will be completed by creating this predictive model in GaBi, the industry standard software for creating LCAs. An accompanying user-interface will be developed with I-Report. The scope of the LCA will be from raw material extraction to disposal, including end-of-life (EoL) management strategies such as recycling. Data for the LCA will be from the GaBi database or collected from Deckers. For ease of use, I-Report, an extension software of GaBi, will serve as the interface between the user and the model.

If time permits, Deckers' Teva brand will also be analyzed. Training material for Simple Shoes designers will also be created for an easy transition into the new software. If feasible, cost accounting will also be conducted using the GaBi software. Feasibility will depend on the details of costs of materials and processes obtained from Deckers. If the data is sufficient, then prices can be assigned to the LCA model in GaBi. Recommendations will also be made to Deckers on strategies to improve their environmental performance by focusing on the most impactful life cycle phase.

Results on the GaBi software include scientifically accepted impact indicators such as global warming potentials, as well as more value-based ones like ecotoxicity potential. Since the environmental impact output of GaBi can be complicated and difficult to interpret, the information will be translated and simplified into several comparable values. These various indicators will be selected according to the value judgments of Deckers and after consulting relevant literature.

3. Significance

The number of shoes purchased by consumers in the United States has increased by more than 200% since 1980 (AAFA, 2007). Within the same time frame, the percentage of outsourced footwear production for U.S. consumption has increased from 50% to nearly 99%. China, where Deckers' shoes are produced, manufactures 85% of this outsourced footwear (AAFA, 2007). Because primary production is typically the dirtiest stage of the supply chain, the dramatic increase in the outsourcing primary production has resulted in the shift of the environmental burden to developing countries that exhibit laxed environmental regulations and lack sufficient enforcement (Cote-Schiff Kolp, 2009). U.S. consumers have become increasingly aware of the impact of their purchasing decisions on the environment and are demanding more environmentally responsible production (Allen & Kovach 2004). This shift in market demand creates opportunity for more sustainable operations in footwear production.

Deckers Outdoor Corporation developed their Simple Shoe brand to be an environmental leader in the footwear industry (www.simpleshoes.com, 2009). Deckers' chosen niche for their Simple Shoe brand is the green consumer. Simple Shoes has claimed to be a "sustainable" footwear brand, but this assertion was not supported by quantifiable evidence until recently (Albers et al., 2008). In their study, Albers et al. conducted a retroactive Life Cycle Assessment (LCA) of four styles of Deckers' products.

As illustrative as this study was, it was still a post-hoc analysis; it would be more effective and efficient to determine the environmental impact of the shoes prior to manufacturing. Currently, Deckers' footwear designers and manufacturers do not have a simple way to assess the environmental impact at any phase of their product's cradle-to-gate supply chain before the shoes are produced. Without a predictive measure of environmental impact, Deckers runs the risk of adopting a material or process that is more harmful to ecosystems, only to discover negative impacts upon retroactive assessment.

This project entails creating a predictive model, or "calculator," to assess the environmental damage associated with chosen footwear materials and manufacturing processes prior to production. By creating this model, Deckers will be able to design shoes with minimal environmental impact. Additionally, because the design of shoes is solely to Deckers' discretion, this model will significantly decrease the uncertainty of the environmental impact expected to take place for a selected design.

4. Objectives

4.1. Primary Objectives:

- *To develop a predictive environmental impact "calculator" that can be used in the design phase of the shoe.*

The primary goal of this project is to create a model that can be used to quantify the environmental impact of Simple Shoes prior to manufacture. Unlike traditional life cycle assessments (LCAs), this model will be used during the design phase of the product rather than retroactively. In the design phase, the form, the material input, and colors are decided. The primary focus of the model will be on the materials, processes, logistics, and end-of-life management strategies that directly relate to the production of different shoe design. The model will be designed using PE-International's GaBi 4.0 software, which is the premier tool for conducting LCAs. I-Report will be used to create a user-friendly interface between the GaBi model and the designer. Training materials will be created to facilitate use of the model by Deckers.

- *To produce an environmental scoring system for shoes*.

GaBi results are difficult to interpret. Therefore, the results will be translated into simplified comparable values. The calculator will produce an output of several indicator categories to quantify the environmental footprint of its current and potential product line-up. The impact categories will be based on a review of scientific literature, simplification of GaBi outputs, and Deckers needs.

- *To make recommendations to Deckers about how to reduce the environmental impact of their shoes.*

The current line of Simple shoes will be assessed for its environmental impact using the calculator. Based on its results, recommendations will be made to Deckers on how they can reduce the environmental impact of their shoes.

4.2. Secondary Objectives:

- *To incorporate monetary costs of materials, manufacturing processes, and other possible inputs into the predictive model.*

If feasible, a cost analysis will be incorporated into the environmental calculator. This would allow Deckers to balance the environmental performance with costs during the design phase. Additionally, Deckers will gain the ability to predict the cost of a shoe during the design phase.

- *To assess the environmental impact of the Teva brand shoes.*

Initially the analysis will focus on the Simple Shoe brand but if time permits Deckers' Teva brand will also be analyzed. Based on the analyses, recommendations on improving the environmental performance of Teva can be made as well.

- *To expand the scope of the LCA model to incorporate indirect resource consumption.*

If data is readily accessible and incorporation into the GaBi data is feasible, indirect processes that relate to shoe production will be included. Such indirect resource consumptions include electricity and water use in manufacturing facilities.

5. Literature Review

5.1. Life Cycle Assessment

Life cycle assessment (LCA) is a process used to analyze the economic and environmental tradeoffs of a product or technology (UNEP, 2004). As the name suggests, the environmental impact of a product or technology is tracked along its entire *life cycle*, ranging from raw material production to EoL disposal in what is called a *cradle-to-grave* approach (US EPA, 2006). Typically, a comprehensive LCA would account for all inputs of raw material and energy required for the duration of a product's lifespan from manufacture, use and maintenance phase, to EoL (US EPA, 2006). Depending on the type and volume of input required, outputs to the environment, such as carbon dioxide, are tracked throughout the life cycle.

The process of LCA was developed during the 1960s, when concerns about natural resource scarcity first became prominent (US EPA, 2006). The Coca-Cola Company was the first major firm to conduct a voluntary analysis, and this became the basis for current LCA projects in the United States. Using a process similar to the modern LCA in 1969, the company determined that plastic bottles were less harmful to the environment than glass, due to the weight difference and its effect on transportation efficiency (ecomii.com, 2009). Interest in LCAs waned in the next decades until the issue of solid waste became prominent in 1988 (US EPA, 2006). Concerns over methodological inconsistencies were voiced by manufacturers, and the International Standardization Organization (ISO) developed a standardization of LCAs in 1997. The ISO 14040 and ISO 14044 have been revised many times since their inception, and are now in the 2006 edition.

According to the United States Environmental Protection Agency (USEPA), a comprehensive LCA consists of four stages: goal definition and scoping, inventory analysis, impact assessment, and interpretation (2006). In the goal definition and scoping phase, the type and accuracy of information and method needed for meaningful interpretation is determined. During the inventory phase, all the necessary input data are collected. In the impact assessment, the data are evaluated for its impact on the environment and human health. Finally, the interpretation phase is the conclusion and recommendation stage of LCA.

Companies can work with consultants to design simplified models that are based on widely accepted LCA software, but tailored to meet the company’s specific needs. For example, Corti et al. (2008) designed a tool, called the *Environmental Packaging Impact Calculator (EPIC),v* to evaluate the LCA of packaging materials for Toyota Motor Sales (TMS). The model gives three different result outputs: a life cycle cost comparison, an environmental indicator comparison, and a table listing substances of concern. The complex results from the GaBi 4.0 software are simplified for TMS into the company’s five “Areas of Concern:” Climate Change, Resource Depletion, Human Health and Toxicity, Air Pollution, and Substances of Concern. The user-friendly EPIC calculator allows packaging engineers to enter readily available information and receive LCA results, as well as the life cycle cost. Since EPIC is a “decision support tool,” it allows for the simultaneous calculation of two packaging systems so that they can be compared. LCA itself will not identify the optimal method for minimizing cost and environmental impacts. As a result, the scoring system modeled for Deckers products will be based on the scientific results derived from the LCA analysis, as well as value judgments based on scientific literature and the client's priorities.

5.2. Common Assumptions of LCA

Life cycle assessment is designed to track material and energy inputs for the life cycle of products convert the resulting outputs into various categories of environmental indicators (ISO 14044, 2006). Some indicators are based on scientifically accepted methods, such as the global warming indicator; some are more value-based, such as human ecotoxicity.

Assumptions must be made for various aspects of LCAs in order to minimize time and cost. Moreover, there may be a lack of available data and access to such information or time constraints (Albers et al. 2008). For example, some unique materials used in Simple Shoe products such as, cork, jute, and bamboo, were not incorporated into the LCA because data related to cultivation and the supply chain was unavailable (Albers et al.,. 2008). Material inputs for agricultural activities such as water and pesticides are often difficult to find. Inputs into agricultural products often vary widely, and information on the production of chemical pesticides is often unavailable therefore excluded from LCAs (Franklin Associates, 2007).

In addition to such assumptions, an LCA project must ultimately establish a scope to limit the materials and processes considered in the study (ISO, 2006). Such a study can potentially include detailed inputs: environmental impact of building the facility and its manufacturing equipment; energy input of cooling the buildings; and energy and wastes associated with R&D (Franklin Associates, 2008). However, a study might exclude superfluous processes that do not have a significant outcome. In their study on packaging for TMS, Corti et al. (2008) concluded that different packaging choices would not significantly impact inventory methods; therefore, inputs attributed to inventory were excluded.

Furthermore, recycling processes require assumptions concerning the allocation of environmental impacts. Recycled products that enter other supply chains (e.g. produced car tire made into shoe sole) present challenge of where to allocate the environmental impact of the original product (ecodesignguide.dk, 2005). For their EoL analysis, Albers et al. (2008) excluded recycled materials, such as car tires because the impact of its primary production should not be attributed to shoe soles. The environmental impact of a material (e.g. car tire) should only be accounted for in the initial production, not the secondary life cycle. Determining the tradeoffs from recycling is complicated because there are many possible alternative EoL management strategies for tires: placement in a landfill, incineration, or recycled for other purposes. The project will use the common method of avoiding these allocation problems by including the benefits of offsetting virgin materials (e.g. rubber shoe sole) in production (Nyland et al., 2003).

5.3. Environmental Impacts of Shoe Production

According to recently completed work n the LCA of Simple Shoes, material production and assemble determine about 90% of the environmental impact of shoe production. The remainder of environmental impacts caused by footwear is due to transportation, packaging, and end-of-life scenarios (Albers et al, 2008). No matter the materials of the shoe, the manufacturing processes of shoes certainly contribute to the overall environmental impact of footwear. Cutting, stitching, sewing, gluing, finishing and packaging involves the use of machines and equipment, such as dye cutting machines, industrial sewing machines, lasting machines, mold pressing machines, EDI machines, conveyor belts, rubber rollers, and vulcanization ovens (Cote-Schiff Kolp et al., 2009).

Of the raw materials that go into shoe manufacturing, cotton, leather and rubber/latex are among the most environmentally damaging. Cotton farming is responsible for 2.6% of the world's water use (Chapagain, 2005). Conventional cotton in particular requires large amounts of pesticides and fertilizers and causes a great deal of water pollution (Chapagain, 2005). In fact, cotton is the most insecticide intensive crop in the world, accounting for 25% of insecticide usage worldwide and 10% of all pesticides usage (Allen Woodburn Associates, 1995). Genetically modified (GM) cotton, particularity Roundup Ready cotton, encourages frequent herbicide use as a way to control weeds and increase yields (Benbrook, 2003). The pesticides used on cotton, such as organophosphates, are among the most dangerous classifications of pesticides available on the market today (PANNA, 2008). Pesticides used on these crops drift into the air, soil and water, causing negative health effects for people and the environment (PANNA, 2008).

Leather suede, which is harvested from cow hide, causes substantial negative environmental impacts, from toxic chemical contamination to high global warming potential (Cal EPA, 2007). Ninety percent of all tanning processes use hexavalent chromium, a compound that has been identified as a carcinogen without safe exposure levels (Cal EPA, 2007). This process of tanning also produces high levels of volatile organic compounds (VOCs), which are known to create surface-level ozone and create particulates and cause respiratory illnesses (Cal EPA, 2007). Tanning effluent also creates wastewater with high amounts nitrogen, sulfides, chromium and chloride as well as introducing chemicals lowering the amount of oxygen in waterways (Subramani et al., 2008; Cal EPA, 2007).

Aside from tanning, raising cattle has a host of negative environmental impacts. Cattle are a significant worldwide generator of greenhouse gases (GHGs) and contaminate waterways with high levels of nutrients (Joseph and Nithya, 2009). Ranching also consumes a large amount of water and energy in feed production and transportation (Leggett 2006). However, leather is a bi-product of the beef and dairy ranching rather than the primary economic driver for these industries and therefore cannot be allotted the full impact of cattle production in a life cycle assessment.

Latex/rubber also has significant environmental impacts, particularly during the processing phase. Latex processing requires 25 to 40 times more water (in volume) than its manufacturing process produces (WWF, 2005). The effluent from the process contains a high amount of organic matter and inorganic chemicals that lower the dissolved oxygen content in waterways (WWF, 2005). The vulcanization process, by which rubber is processed, requires lead and zinc: both metals have negative environmental health consequences. Lead is well known as a toxic chemical, causing nervous system damage, slowed growth, hearing problems, headaches reproductive problems, hypertension, and muscle and joint pain (US EPA, 2009). Although it is much more benign than lead, zinc has many negative impacts on aquatic invertebrates. Vulcanization accounts for 25% of all anthropogenic zinc released into the environment (WWF, 2005).

5.4. Company Response to Consumer Demand

As American consumers become more aware of the environmental impacts of their consumption habits, they have driven companies to become more environmentally sensitive (Hoffman, 2000). The availability of environmentally friendly products in stores such as Walmart attests to the power of green consumption (NY Times, 2005). As a consumer driven industry, the footwear industry has been quick to adopt the idea of environmental corporate social responsibility and companies such as Deckers, Nike, and Patagonia have taken steps to reduce their environmental impact.

Environmental corporate social responsibility (CSR) helps companies by increasing benefits from societal appeal and minimizing risks and liability from environmental regulations. Benefits come from the customers' increased willingness to pay for the differentiation of the product, improved employee retention rates, higher employee productivity, and recruitment of better quality employees (Hoffman, 2000). Risks are minimized by preempting regulations, increasing barriers to competition through strategic differentiation, and helping government entities design new regulatory structures (Reinhardt 1998). However, in order for environmental CSR to be effective and beneficial for companies like Deckers, it must be able to ensure its actions are credible and visible to their target audiences (Reinhardt, 1998).

In order to determine the environmental impact of their products, many companies have conducted a full or partial LCA. New Belgium Brewery is one of the leaders in sustainable business practices. As part of its environmental CSR, the company has calculated the carbon footprint of its products. New Belgium Brewery initially focused on one brand, a 6-pack of Fat Tire® Amber Ale, before expanding to the rest of its products. They found the carbon footprint to be 3,188.8 grams of CO_2 (New Belgian Brewery, 2009). New Belgium Brewery has an ongoing effort to reduce their per barrel carbon footprint by focusing on the life cycle phases that have the most significant impacts.

Patagonia has been an environmental leader in the outdoor apparel industry with its environmental commitment extending into footwear design. In order to minimize the need for their customers to buy new shoes, Patagonia's *Sugar & Spice Shoes* are made from detachable components held together using minimal glue. Therefore, if one component wears out, an owner can replace it without buying a whole new shoe (Patagonia, 2009). Levi Strauss & Company has also measured the cradle-to-grave (from resource extraction to disposal) environmental impact of two of their products: Levi's 501 Jeans and Dockers Original Khakis (PE Americas, 2008). Their assessment covered the impacts of water consumption, climate change, and energy use. From the study, Levi's concluded that the most harmful phase of the products' life cycles is the consumer use phase (PE Americas, 2008). In order to reduce the company's environmental impact, Nike has committed to reduce waste generated across their entire supply chain, to use more environmentally benign materials, to reduce CO2 emissions, to use innovative chemistry to eliminate toxins and waste, and to create closed-loop products and business models (Nike, 2009).

New Belgium Brewery, Levi Strauss & Company, Patagonia, Nike, and Deckers all have unique ways of evaluating the environmental impact of their products. This led them to reach different conclusions as to where the majority of environmental impacts were occurring. Nike developed the “Nike Considered Index” which evaluates materials, solvents, waste, garment treatments, and innovation. Products are assigned a "Considered" score using an index framework based on Nike's known footprint in these areas (Nike, 2009). Only products whose score significantly exceeds the corporate average can be designated as "Considered" relative to the company’s known footprint. In New Belgium Brewery’s LCA of the 6-pack, the largest contributor to greenhouse gas emissions (48% of total emissions) was in upstream emissions during production and transportation of packaging materials and beer ingredients, followed by downstream emissions from distribution, retail, storage and disposal of waste (46.6% of total emissions). In the LCA of Levi Strauss & Company’s two products, the most significant environmental impacts in terms of global warming potential, energy use, and water use, all occurred during the consumer use phase of the product (PE Americas, 2008).

Albers et al. (2008) conducted a complete LCA for four designs of Deckers’ Shoes to assess the cradle-to-grave environmental impact of each shoe. To assess the environmental impact, they used ten environmental impact categories provided by GaBi 4.0 software, including ecotoxicity potentials, acidification potentials, climate change potentials, and hazardous materials. Albers et al. (2008) found in their LCA that the most significant environmental impact of all four shoes was in the toxicity potential. The acidification potential, and factors associated with global warming were affected to a lesser extent, but because the robustness of the environmental impact categories is under debate among international experts, the authors recommend balancing efforts to reduce different environmental impact categories (Albers et al., 2008).

Albers et al. (2008) also found that the materials production—leather, synthetic material, and plastics in particular—and manufacturing phase were the most impactful phases. The relative degree of impact is followed by the end-of-life (EoL) phase, and transportation. Packaging was found to be the least impactful. Hemp, organic cotton, and crepe rubber were found to have the lowest global warming potential. Materials production and assembly were found to be responsible for nearly 90% of the environmental impacts. Due to a limited time frame, Albers et al. (2008) were unable to conduct sensitivity analyses; therefore the robustness of their findings should be verified.

6. Approach

6.1. Goal and Scope

The LCA will be conducted using GaBi, a software considered an industry-standard for LCAs. This assessment will take into account the materials and processes data. A companion program, I-Report, allows for designers to interface with the model using simple and predetermined parameters (e.g. type of material, amount of material, etc.).

Due to the client's desire for a model that can be used across different shoe brands and supply chains, the LCA model must allow for flexibility and simplicity for user inputs. To a certain extent, this flexibility will come at the cost of accuracy because it will not be possible to take into account all nuances for a specific shoe line's life cycle. However, Deckers specifically requested that the calculator have a large scope. Shoe designers, as the primary users of the calculator, will likely have information pertaining to the amount of material and basic manufacturing process used to produce the shoe, but not necessarily of the energy and water consumption associated with making the shoe.

A system boundary will be determined for the project. For example, the project will not include the material and energy inputs required for building maintenance (air conditioning, lighting, etc), and inputs required for building the factory equipment will not be included. Those inputs considered to be outside of our LCA scope will not be implemented in the project (Figure 1).

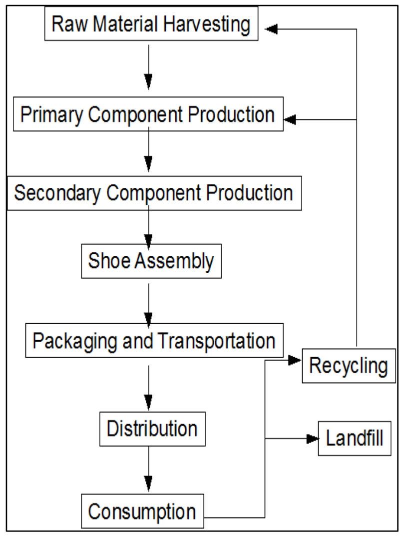

Figure 1. The processes and flow (system boundaries) for the manufacturing of a shoe.

According to Albers et al. (2008), material extraction and manufacture have the greatest environmental impact. Therefore, the calculator will primarily focus on these phases. Additionally, the model will be designed to incorporate the positive effects of keeping materials out of the waste stream because Deckers uses several recycled materials in its products.

6.2. Inventory Analysis

The majority of data necessary for input into the GaBi model will be collected during the inventory phase of LCA. Input data will include:

- Materials,
- Manufacturing processes,
- Distribution network,
- Distance or volume for all input.

Much of the data required for the model will be available in the GaBi database. Information for raw materials (rubber, cotton, plastic, etc.) as well as information on basic transportation methods (freight ship, trucks, etc.) are available on GaBi. However, specialized processes such as vulcanizing rubber shoe soles and cold cementing will require additional research to obtain usable data. Obtaining data of these processes will involve interacting with Deckers contacts in Chinese factories. If possible, the data will be verified by comparing similar information across multiple suppliers in China.

Information on the volume of material flow will come from Deckers' "Bill of Materials" (BoM). The BoM is essentially a formula for creating a certain shoe: each individual material and the amount required for product construction is listed. Since the BoM is available for all Deckers products, collecting information on material flow should not be difficult. However, information regarding the manufacturing process of the shoes will be more challenging to collect, as it involves communicating with factories in China.

The distribution network, transportation distance, and payload (how much the vehicle is filled with product) will be obtained from Deckers. This will allow for a model of distances and transfer mode of each product to be incorporated into the GaBi model. Some assumptions made by the 2008 Simple Shoes group will be reevaluated for the current project. For example, the consumer use phase was considered to have negligible environmental impact, and the lifespan of the shoes were assumed to be uniform (Albers et al., 2008). All natural fibers were assumed to be generated through a process similar to that of cotton, therefore the cotton production process is representative, and material loss due to processing is excluded. In terms of transportation, it is assumed that trucks, truck-trailers, and ocean container ships were vehicles utilized in the supply chain, and that the utilization ratio (percentage of the payload actually used) is 85%. Albers et al. (2008) assumed that all distances from Simple Shoes Ventura to the point of sale were uniform. Finally, an EoL assumption is that the disposal of municipal solid waste is handled on a per county basis in the U.S.

6.3. Incorporating Data into Model

The data will be incorporated into the LCA software, GaBi, and integrated into a single product system. In GaBi, the basic material flows are connected to the appropriate processes on a visual user interface. The volume of environmental output tracked by the software will be dependent on the amount of flow into the processes. As the materials are transformed by processes and transported along the product life cycle, GaBi tracks the corresponding output for future analysis.

6.4. I-Report

The outputs from the GaBi software are difficult to interpret for people who are not trained; therefore, a simplified user-interface will be created. For this purpose, GaBi’s extension software I-Report will be utilized. I-Report can be used to create an interface containing input parameters that operators can enter to obtain output for a design of a shoe. The inputs into I-Report incorporate the inputs into the underlying GaBi model to produce the desired environmental indicators. The calculator must only contain parameters for information which designers will have access to (e.g. material type, amount of material, manufacturing process, etc.) but at the same time, must be accurate enough to allow developers to compare relative environmental impacts of various designs. This ability will allow for the substantial reduction of the uncertainty of its actual impact upon manufacture.

6.5. Model Verification

Once the model with the associated user interface is developed, it will require testing for accuracy between its outputs. A known, predictable change will be made in the material or process flow of the model itself, and its effect on the environmental impact will be assessed. The same change will be made on the I-Report interface and its accuracy by comparing to the environmental outputs of the model itself will be assessed. An assumption must be made that once the model is deemed complete and accurate (though there will likely be continual adjustments), changes in its parameters reflects real-life situations. A case study of actual supply chain changes will be beyond the project's time horizon.

6.6. Sensitivity Analysis

A sensitivity analysis will be performed to assess the relative contributions of variables to environmental impacts. This test will be performed by changing a single category of flows in the model, such as materials, processes, or transportation, and assessing its impact on the resulting output change. As shown Albers et al. (2008), it is expected that raw materials will have the largest environmental impact.

6.7. Environmental Categories

Although I-Report may be used to make the inputs more meaningful to the designers, its outputs remain complicated environmental indicators, such as global warming potential, acidification potential, etc. In order to make the output more relevant to the person operating the model, multiple outputs will be condensed into environmental impact categories. The environmental categories will be developed and weighted based on the outputs from GaBi, scientific literature on developing environmental scoring methods, and value judgment by Deckers.

6.8. Training material

Once the model is successfully completed, training material will be created for Deckers. While the interface will be designed to be intuitive, this training material is necessary to ensure that the input parameters are understood correctly. The training material will also specifically address results, assumptions and limitations, data quality assessment, and transparency of value choices and judgments. It will also provide methods of interpreting the output of the calculator, explaining that is it a relative value to be translated to relevant terms such as “good,” “fair,” or “poor” for the environment. The training manual will be given to Deckers employees and revised as needed.

7. Management Plan

7.1. Footprint Team

Ariana Arcenas *Project Manager*

- Schedule meetings using CT
- Send out meeting agendas
- Facilitate group meetings
- Maintain Google calendar
- Set final deadlines
- Ensure that deadlines are met
- Make final decisions after listening to all sides if a compromise cannot be met

Julie Holst *Data Manager & Presentation Specialist*

- Manage documents within the GP folder
- Design an organization system for the GP folder
- Ensure that documents remain organized within the folder
- Transcribes Minutes at meetings and files a copy in the GP folder
- Complete slides and scripts for presentations
- Primary Contact with Deckers

Takuma Ono *Web Manager*

- Design GP webpage
- Manage all web content
- Primary contact with PE America

Matt Valdin *Financial Manager*

- Set and manage budget
- Track expenditures
- Primary Contact with external advisor, Brandon Kuczenski PhD Candidate
- Plan monthly fun activities

Notes: Roles will remain as assigned throughout the duration of the project. However, if anyone is unhappy with the roles as designated, the management structure and roles can be re-assessed and re-assigned at the beginning of each quarter.

7.2. Bren Advisors

Sarah Anderson *Primary Faculty Advisor*

- Attend weekly meetings throughout the Spring Quarter
- Provide feedback on project scope and advice on the project.
- Review products as they are completed provide feedback within a week of receiving the product.

Roland Geyer *Secondary Bren Advisor – LCA*

- Assist with LCA questions
- *Read the project proposal and provide feedback*

Brandon Kuczenski *Secondary Bren Advisor - LCA*
- Assist with LCA questions
- Read the project proposal and provide feedback
- Attend the review committee meeting

Patricia Holden *Secondary Faculty Advisor – Environmental Impacts*
- Assist with environmental impact questions
- Read the project proposal and provide feedback
- Attend the review committee meeting

7.3. Deckers Team

Mark Fegley *Deckers, Senior VP Supply Chain*
Monica DeVreese *Simple Shoes, Brand Manager*
Abigail Nugent *Simple Shoes, Product Coordinator*
Cielo Rios *Simple Shoes, Product Line Manager*
Ron Hillas *Deckers, Materials Sourcing Manager*

7.4. Meetings

Weekly meeting: For Spring Quarter 2009, we plan on having a weekly meeting from 9am to 11am on Tuesday in the Bonsai Room. Sarah will come to the second half of our weekly meetings. The PM will schedule weekly meetings at the beginning of each quarter.
Regular meeting with Deckers: We hope to meet with a Decker's representative at least once each month and hopefully every two weeks initially.
Additional meetings: We understand that meetings beyond the weekly meeting will be required throughout the process. However, we will do our best to avoid holding meetings one day of the work week (Wednesday during Spring 2009). If a weekend meeting is required, we will hold it at 6pm on Sunday.
Agenda: There will be an ongoing weekly agenda in a running Google document that will be used to compile issues that need to be discussed at the next meeting. On Monday, the PM will email the final agenda to all group members and the Advisor.
Minutes: The DM will take minutes on the running Google document and will file a copy of the minutes in the appropriate folder immediately following the meeting.
Missing meetings: If a group member knows in advance that he or she will miss a meeting in whole or in part, that group member must notify the rest of the group members. All internal deliverables must be submitted before the meeting.
Leaving town: Group members should be able to leave town throughout the process, within reason. However, as soon as someone knows that he or she will be out of town, it should be entered into the GP Google calendar. This includes leaving for the summer and during any school vacations.
Fun activities: We will try to get together for fun once a month.

7.5. Communication

Email etiquette: ensure that the subject line matches the email content and always check who the email is going to.
Important communications: if a question or comment is urgent, send a text message.

7.6. Document Management

Google Documents: will be used for the following working documents: current agenda/minutes and ongoing literature List
GaBi: A record will be maintained tracking changes made in GaBi and when they are made.
Drop Box: will be used to store all files, documents, data, spreadsheets, emails, and any other media. Each group member will have a personal folder within the main directory. Only the DM can delete files, with the exception of files within personal folders. The DM will monitor the folders to ensure that they remain organized.
Ready to use images file: will be used for any images that can be used in the report. All files in this folder MUST have all copyright approval. The document will also contain an image citation list which is an excel document with the document name and the citation.
Literature List: A working list of all literature used in the project will be maintained.

7.7. Quality Control

Internal Deliverables: Each deliverable is "owned" by a particular person, who is responsible for ensuring that it meets the internal deadlines. Deliverables must be of equivalent quality to a final product.
Document formatting: All documents must follow the formatting specified in the formatting guideline, which will be revised throughout Spring 2009.
Editing: Each group member must read all final documents. All final documents must go through a full round of edits. Edits will be done sequentially but the editing order can be changed if anyone is unhappy with his or her position with the agreement of all other group members. The current order is: (1) Ariana (2) Matt (3) Julie (4) Takuma
Document submission: The final editor will submit all documents.

7.8.Deadlines

A Google Calendar has been created with project deadlines and individual deadlines.
The PM will monitor the calendar and send out reminders as deadlines approach.
In general, individual deadlines will be due at the weekly logistical meeting, and updates will be made at the weekly logistical meetings.
If a deadline cannot be met, that group member must notify group members as early as possible if an extension is needed.
Be honest about the amount of work that you have but also plan GP into your schedule

7.9 Conflict Resolution

Avoiding intergroup conflict: If any group member is concerned about another group member or an idea, he or she should communicate their feelings to the other group members. In return, group members must trust the other people's intentions and be open to constructive criticism. Try to maintain a high level of communication, even if it seems superfluous at the time. If a conflict does arise, use the following steps:

1. Try to talk to the person
2. Talk to PM
3. Group meeting
4. Talk to Sarah
5. Contact the Bren Administration or UCSB Ombuds

In case of conflicts with the Advisor or with the Client: Contact the GP Coordinator, Amy Burgard.

7.10. Guidelines for interacting with clients

Emails: CC all group members on all emails to non-Bren people. Any important email communications, and any communications with people outside of Bren, will be copied or scanned and put into the drop box.

Meetings with clients: We will ensure that we will have a prepared agenda for any meeting with clients.

8. Timeline and Milestones

8.1. Spring 2009

- Create website
- In class presentation
- Write Project Proposal
- Submit data request to Deckers
- Finalize software selection and installations
- Appoint External Advisory Committee and Advisory Board

Task Name	5/04	5/11	5/18	5/25	6/1	6/8
Methods Section						
Website Development				5/29		
Draft Proposal			5/18			
In class presentation		5/14				
Final Proposal				5/26		
Data Requests to Deckers					6/5	
Software finalized						
Review meeting						

8.2. Summer 2009

- Data Collection
- LCA Analysis

Task Name	July	August	September
Initial Data Collection	■	■	■
LCA Analysis			■

8.3. Fall 2009

Conduct LCA analysis on material inputs, manufacturing processes, and logistics

- Conduct sensitivity analysis to determine the relative environmental impacts of the different inputs and processes
- Create a user-friendly calculator based on I-Report and verify the model
- Conduct case studies on multiple Deckers products
- Collect additional data as necessary

Task Name	Sept		October				November				December		
	9/21	9/28	10/5	10/12	10/19	10/26	11/2	11/9	11/16	11/23	11/30	12/7	12/14
LCA Analysis	■	■	■	■	■	■	■	■	■	■	■	■	■
Sensitivity Analysis								■	■	■	■		
Integrate with I-Report								■	■	■	■	■	■
Verify Model												■	■
Conduct Case Studies									■	■	■	■	■
Ongoing data collection	■	■	■	■	■	■	■	■	■	■	■		

8.4. Winter 2010

- Write draft of Project Report
- Write draft project training manual
- Create project brief
- Create project poster
- Defense
- Complete Final Report

Task Name	January					February				March			
	12/28	1/4	1/11	1/18	1/25	2/1	2/8	2/15	2/22	3/1	3/8	3/15	3/22
Refine and Improve Model													
Draft Report								2/15					
Draft Training Manual													
Create Project Brief												3/19	
Project Defense													
Final Report												3/19	
Project Poster													

8.5. Spring 2010

- Project Poster
- Community Presentation

9. Deliverables

- I-Report Calculator
- Training Manual
- Case Studies

The following budget reflects cost of the project under alternatives 1 and 2 listed on the following page. The large variance in costs is largely a result of the uncertainty as to whether it is necessary to purchase supporting databases for Deckers to use.

10. Project Budget

Category	Amount ($)	Remarks
To be purchased with Bren GP Funds		
Poster	$140-$470	Depends on Printer/Number of Prints
Final Project Prints	$50-$100	Depends on Number of Prints
Supplies	$50	For folders and other supplies
Miscellaneous	$300	
Total	**$590-$920**	
To be purchased by Deckers		
GaBi Reader	~$3,500	Purchasing of GaBi Reader allows for Footprint GP full access to necessary software
Total	**$3.500**	
Grand Total	**$4,090-$4,420**	

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