measuring and valuing environmental impacts

A Systematic Review of Existing Methodologies

Network for Business Sustainability

Business. Thinking. Ahead.

Prepared by
Dr. Pamela Kaval

Humans caused $6.6 trillion in environmental damage in 2008[1].

[1] Trucost. 2011. Universal Ownership: Why Environmental Externalities Matter to Institutional Investors. Commissioned by UN Principles for Responsible Investment (PRI) and UNEP Finance Initiative.

But it's hard to manage what you can't measure. How can you measure and value your organization's the environmental impacts?

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Dear Reader,

Growing public awareness of environmental issues and increasing government oversight have motivated companies to measure their environmental impacts. Such broad interest, however, has also contributed to the proliferation of tools available to measure such impacts. Managers can become confounded by the vast array of options.

I am pleased to share with you this report on measuring and valuing environmental impacts. It systematically reviews the body of knowledge in this area, including 180 studies and 20 tools. It also identifies the pros and cons of the most common tools, enabling managers to select among them dependent on their specific needs. I also encourage you to read the executive report that complements this research. It provides an actionable four-step process for measuring your environmental impacts (available at www.nbs.net/knowledge/impacts).

Dr. Pamela Kaval was the lead researcher on this report. Dr. Kaval was supported by the project's guidance committee, which included Karen Clarke-Whistler (TD Bank Group), Andrew Wilczynski (TELUS), Blair Feltmate (University of Waterloo), Luc Robitaille (Holcim) and Dror Etzion (McGill University). The project has benefitted tremendously from the insights of these sustainability leaders.

This report is one of many NBS has produced. Our Leadership Council, a group of multi-sector organizations leading in sustainability, chooses the topics we investigate. They meet annually to identify and discuss the most salient challenges facing their businesses. Understanding the ways in which businesses can measure and value their environmental impacts was one of the most important issues for 2010. The reports from all their past priorities are available freely on our website at www.nbs.net.

I hope this report will help you identify the tools that can best help you on your journey to managing your environmental impacts.

Sincerely,

Tima Bansal, PhD
Executive Director, Network for Business Sustainability
Professor, Richard Ivey School of Business

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executive summary

Organizations are interested in decreasing their negative environmental impacts, but doing so requires that they first understand what these impacts are.

Many organizations are interested in decreasing their negative environmental impacts, but doing so requires that they first understand what these impacts are. To gain insight into how to determine these impacts, 180 studies were reviewed and 20 tools were identified. 15 of the 20 tools were measurement-based, while five were valuation-based. Only seven of these tools were studied in both academic and practitioner settings: four were measurement-based (balanced scorecard approach, carbon footprint, ecological footprint and life cycle analysis) and three were valuation-based (ecosystem service valuation, sustainability value added and the triple bottom line).

All 20 tools can be used to investigate a firm's environmental impact; however, some are better than others at particular tasks. For example, several tools are more proficient in determining a firm's environmental impact in relation to one product or one event, whereas others are better at evaluating the environmental impact of an entire industry. In addition, some of the tools are well supported by in-depth research and/or readily available guidelines and computer software to assist firms in determining their environmental impact.

The following table lists the 20 tools for analyzing ecological impacts and possible[2] applications for each.

MEASUREMENT-BASED METHODS/TOOLS:	POSSIBLE APPLICATIONS
Balanced Scorecard Approach	To evaluate environmental, social and financial measures
Carbon Footprint	To determine the total amount of carbon dioxide an organization is linked to
Destination Environmental Scorecard	To evaluate the environmental performance of small and medium sized hotel operations
Ecological Footprint	To compare established operations in different locations
Environmental Evaluation Matrix	To appraise the environmental impacts of projects
Environmental Management System Modelling	To evaluate the management of an organization's environmental programs
Epstein Roy Framework	To determine how to modify environmental, social and financial performance
Genuine Wealth Accounting Model	To evaluate environmental, social and financial measures
Green Globes Design	To improve the sustainability and environmental performance of commercial buildings
Green Productivity Index	To integrate environmental protection into corporate performance
Life Cycle Analysis	To evaluate the environmental and social damages related to a specific service or product
Lowell Center Hierarchy	To evaluate environmental, social and financial measures
Materials Flow Analysis	To evaluate the flow of a material through a firm and its affected ecosystems
Responsive Business Scorecard	To integrate stakeholder demands into environmental, social and financial goals
Whole Life Value	To integrate stakeholder values with a life cycle analysis of a product or project

VALUATION-BASED METHODS/TOOLS:	POSSIBLE APPLICATIONS
Cost-Benefit Analysis	To weigh the benefits of a new project, program or product with its costs
Ecosystem Service Valuation	To determine the value of a new construction project on undeveloped land
Environmental Input-Output Model	To determine the total economic, social and environmental value of a product or service
Sustainable Value Added	To increase company efficiency while considering all environmental and social impacts
Triple Bottom Line Reporting	To determine the total economic, social and environmental value of an organization

[2]These are only suggestions and therefore do not represent all applications a tool can accomplish.

You can record environmental impacts as measurements or value: for example, the number of kilograms of CO_2 a smokestack releases annually or the total dollar value of woodland that would be destroyed for a new construction project.

A recent United Nations report found that human activity in 2008 led to $6.6 trillion in global environmental damage, 33 percent of which was caused by 3,000 of the world's largest publicly traded organizations (United Nations Environment Program Finance Initiative, 2010). As such, many organizations are interested in maintaining a record of their positive and negative environmental impacts to be more aptly able to set goals, both to decrease or maintain their level of negative impacts and to increase or maintain their level of positive impacts.

Environmental impacts can be recorded as a measurement or a value. A measurement is simply a technique used to determine the magnitude of a quantity. For example, an organization can determine how many kilograms of carbon dioxide are released annually from a particular smokestack. Valuing an impact, on the other hand, refers to assigning a monetary value to a particular impact. These two terms are, however, not mutually exclusive. Several measurements are financially based, such as the income derived from the sale of products or the cost of shipping, while some valuations initially require a measurement, such as the amount of carbon dioxide released annually from a particular smokestack, before a value can be assigned.

Numerous tools/methodologies currently exist to assist organizations in determining the impact of a product, firm or organization on the environment. However, it is often unclear which tool is best to use in a particular situation. Moreover, although several tools have been studied by academics (e.g., ecological and carbon footprints, life cycle analysis and ecosystem service valuation), much remains left to assumptions and interpretation and no consensus exists within individual methodologies. For example, imagine the owners of an environmentally conscious firm who want to minimize the environmental impact they impose when three of their Toronto (Canada) employees fly to Auckland (New Zealand) for a business trip. One option is to calculate their carbon footprint and pay for carbon offsetting (Gossling et al., 2007; Thomassin, 2003), which would require searching for a carbon offset service; providing the number of people travelling, their destination and travel mode; determining the carbon dioxide (CO_2) discharge and its corresponding cost; and, finally, paying the carbon offset service to offset their carbon footprint.

However, different websites provide different estimations of the carbon offset required[3] (e.g., four tons of CO_2 for a USD56 fee, 9.9 tons for a GBP177 fee and 21.2 tons for a USD538 fee).

[3] The three carbon offset services used to determine the calculations were www.sustainabletravelinternational.org, www.carbon-passport.com and www.brighterplanet.com. These websites were located by conducting a Google search for carbon offsetting.

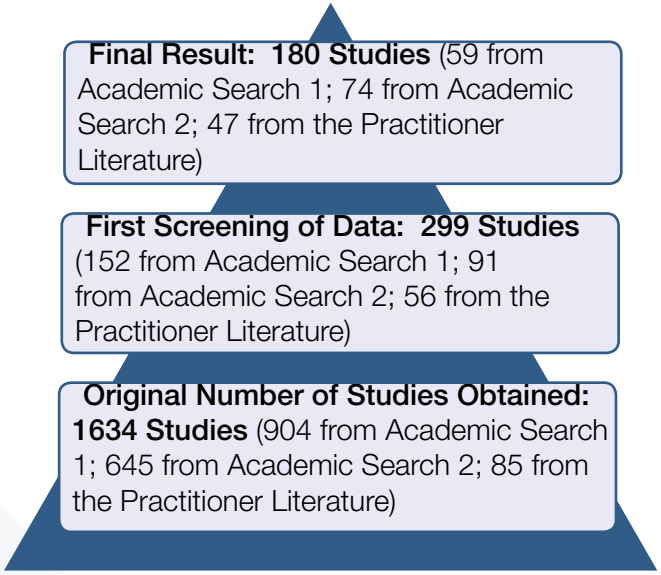
Why are these estimates so different? Were important questions omitted that led to such discrepancies? And why should the firm favour the carbon footprint (Perry et al., 2008; Schulz, 2010; Waddington et al., 2009) over the ecological footprint (Barrett and Scott, 2001; Wackernagel, 1994; Wackernagel et al., 2004), the life cycle analysis (Andrae et al., 2005; Aumonier, 2001; Rebitzer et al., 2004), or the ecosystem service valuation (Costanza et al., 1997; Kaval, 2010; Sandhu et al., 2008).

To provide some insight into these questions, this study provides a comprehensive, unbiased snapshot of the current knowledge on this topic by using a systematic review and synthesis of the most rigorous published and unpublished research and practitioner knowledge on measuring and valuing a firm's ecological impacts. Because the aim of the report is to be valuable to researchers, corporate and non-profit managers, as well as to government policymakers and university educators, the project scope was assisted by an Oversight Committee comprising four practitioners and one academic.

To conduct this review, a concerted effort was made to locate and review relevant studies through three literature searches. The first and second searches focused on the academic literature, while the third focused on the practitioner literature. The collected literature was then collated, and all studies were thoroughly reviewed and analyzed. In total, 180 studies were entered into the database (Figure 1). Please refer to Appendix A for a full report of the search process and Appendix B for the list of references. The completed database was used to create the analytical diagrams and summaries for this systematic review report.

Figure 1

STUDIES IN THE SYSTEMATIC REVIEW PROCESS



state of the knowledge

This review analyzed 180 studies since the year 2000. It found Life Cycle Analysis and Ecological Footprint were the two most commonly studied measurement tools. Environmental Input-Output modeling and Ecosystem Service Valuation were the two most commonly studied valuation tools.

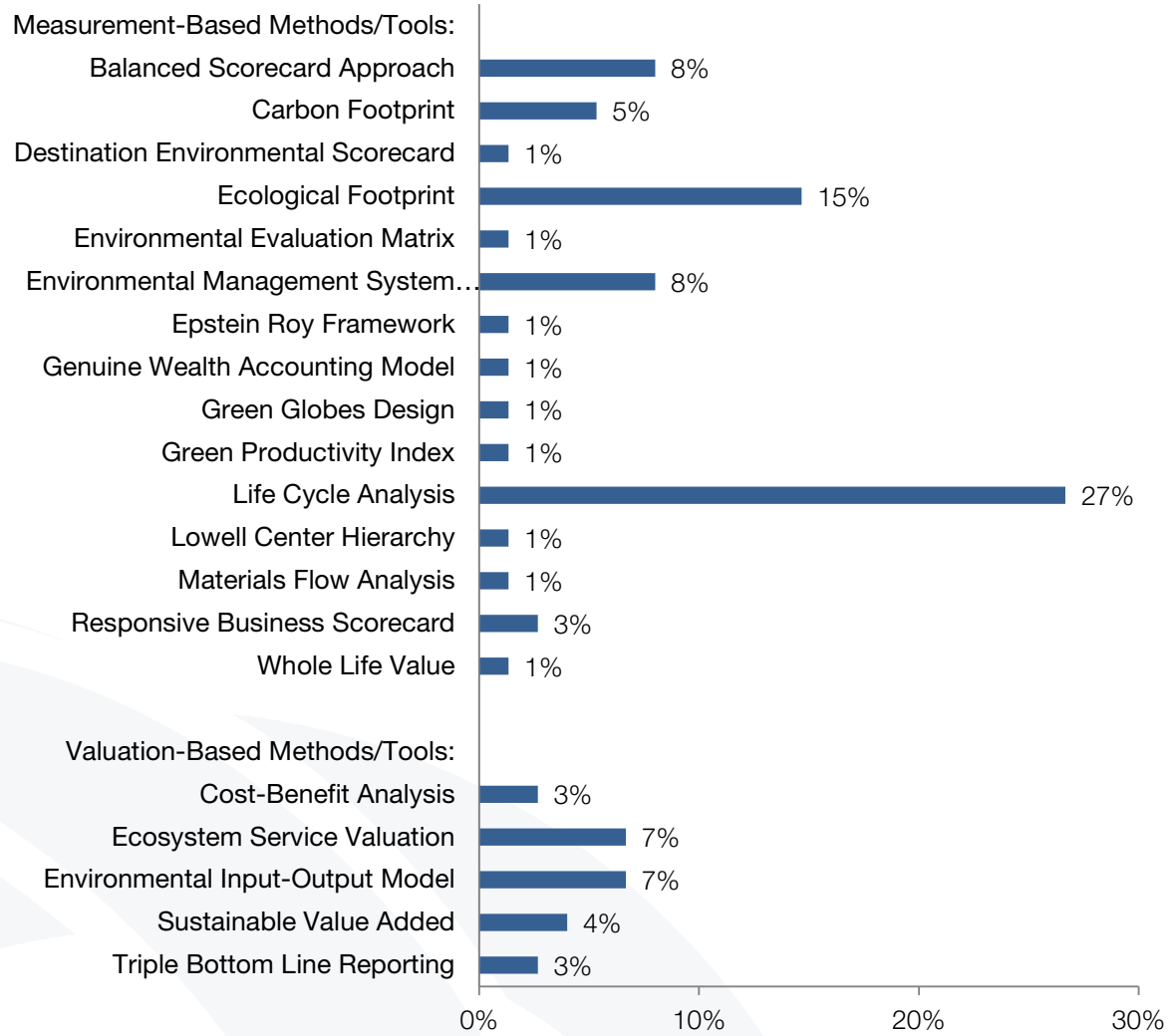
Each of the 180 studies in this review was analyzed across 70 variables. The variables included the source of the study, tools studied, country of study, year of study and the results of the study, to name a few (see full methodology in Appendix A). The analyzed data provide extensive insights into the practices currently being used in relation to measuring and valuing a firm's ecological impacts.

MOST COMMON TOOLS

The database studies were found to focus on 20 methods or tools; 15 of these tools were measurement-based and five were valuation-based (Figure 2). Although the tools were divided into two categories (measurement and valuation), this division does not preclude that measurement tools do not include financial valuations or that valuation tools do not include measurements. Many measurements are financially based and many valuations are measurement-based. The most commonly studied tool of the 180 studies in the database was found to be the life cycle analysis, which appeared in 27 percent of the studies. The next most commonly studied tools were the ecological footprint (15 percent), followed by the balanced scorecard approach (eight percent) and environmental management system modelling (eight percent). These top four methods are all measurement-based. The next two most commonly studied tools were valuation-based, the environmental input-output model and ecosystem service valuation, both found in seven percent of the studies. All other tools were applied in four percent or fewer of the studies. Thus, although the life cycle analysis (a measurement tool) was studied more often than the other tools, it was not studied ubiquitously.

Figure 2

PERCENTAGE OF STUDIES REPORTING THE USE OF A SPECIFIC TOOL



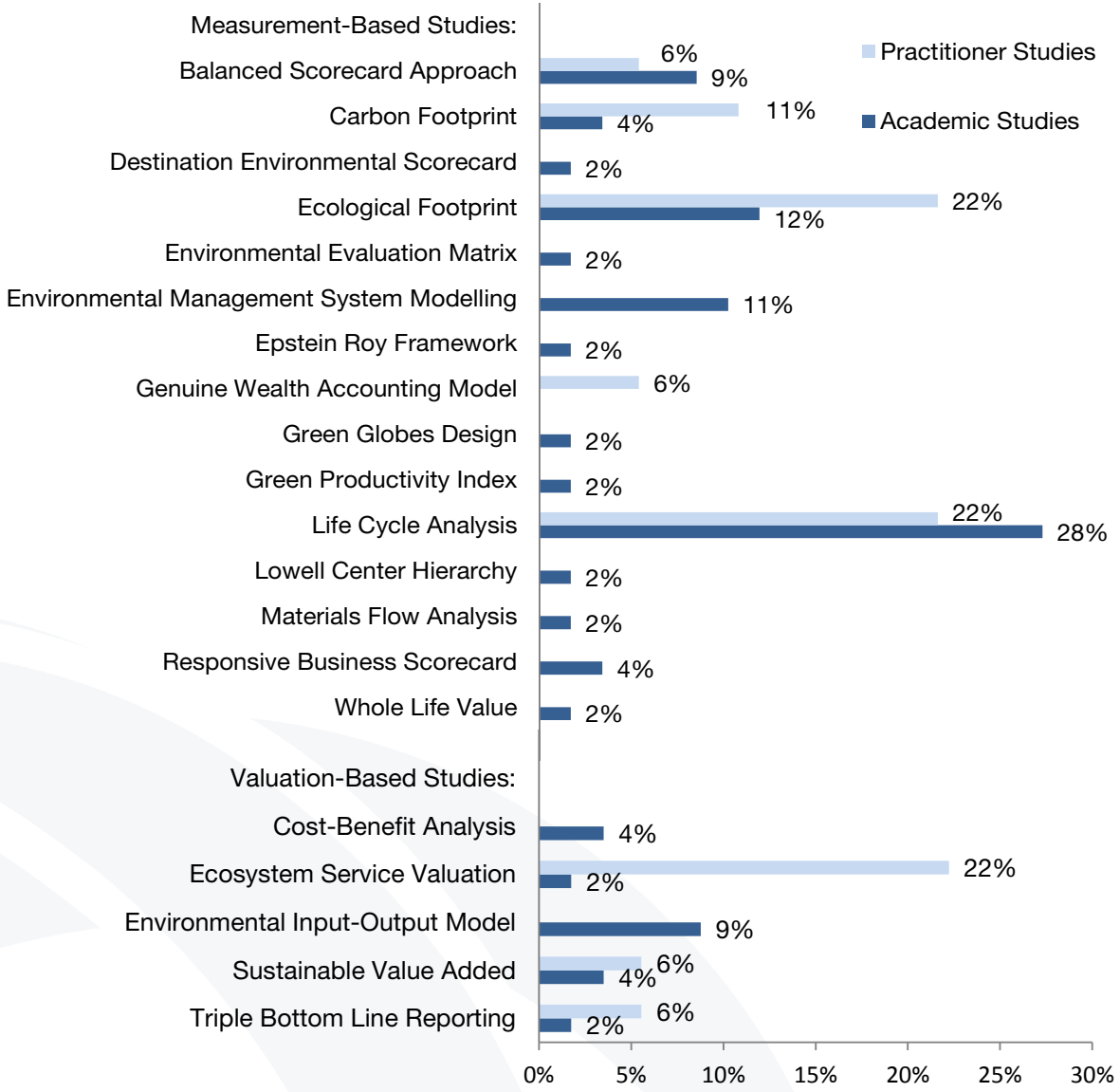
When subdividing the studies into practitioner and academic literature, some interesting results were revealed. The most popular method studied by academics was the life cycle analysis (28 percent), while three methods were equal in popularity for practitioners: ecosystem service valuation (22 percent), the life cycle analysis (22 percent), and the ecological footprint (22 percent) (Figure 3). Two methods were vastly more popular with practitioners than academics: ecosystem service valuation (22 percent practitioner vs. two percent academic) and the ecological footprint (22 percent practitioner vs. 12 percent academic). On the other hand, two methods were more popular with academics than with practitioners: environmental management system modelling (11 percent academic vs. zero percent practitioner) and the environmental input-output model (nine percent academic vs. zero percent practitioner).

Sixty percent (12 of 20) of the tools were only studied by academics, while one tool was only studied by practitioners (the genuine wealth accounting model). Several of these studies were based on the creation of a new method or an update of an old technique termed with a new name. This use of new and revised methods may imply a lack of satisfaction with the currently available methods among both academics and practitioners.

After subtracting the 13 studies used by only one group, seven tools remained. Of these seven tools, four were measurement-based (balanced scorecard approach, carbon footprint, ecological footprint and life cycle analysis) and three were valuation-based (ecosystem service valuation, sustainable value added and triple bottom line reporting). While these results are interesting, care should be taken in their interpretation, as the database included significantly fewer practitioner studies than academic studies.

Figure 3

PERCENTAGE OF STUDIES REPORTING THE USE OF A SPECIFIC TOOL



TRENDS OVER TIME

In the 10 years since 2000 (the time covered in this review), the life cycle analysis tool has increased in popularity becoming the most commonly studied tool since 2004. Interest in the ecological footprint was strong in the 2000–2003 period, waned in the middle of the decade, but resurged in the latter years, ending as the second-most commonly studied tool between 2008 and 2010. Interest in the carbon footprint and ecosystem service valuation seems to have increased in the last few years, as these tools became the second- and third-most popular tools during 2008–2010, respectively, perhaps implying that these methodologies are emerging methodologies (Figure 4).

Figure 4

TOP THREE TOOLS BY YEAR GROUPING

2000-2003	2004-2007	2008-2010
Ecological Footprint (Measurement)	Life Cycle Analysis (Measurement)	Life Cycle Analysis (Measurement)
Life Cycle Analysis (Measurement)	Environmental Management System Modelling (Measurement)	Carbon Footprint (Measurement)
Balanced Scorecard Approach (Measurement)	Environmental Input-Output Model (Valuation)	Ecological Footprint (Measurement)
		Ecosystem Service Valuation (Valuation)

Note that the Balanced Scorecard Approach between 2000-2003 was the only tool discussed in fewer than three studies. In addition, between 2008-2010 the Carbon Footprint and Ecological Footprint tools were discussed in the same number of studies; therefore, they are both second most popular.

Separating the tools by year grouping and study type (academic or practitioner) reveals that academics favoured two measurement-based tools: the ecological footprint was the most popular method during the 2000–2003 period, while the life cycle analysis was the most popular method between 2004 and 2010 (Figure 5). These results are comparable with the results in Figure 4, likely because of the greater number of academic studies compared with practitioner studies.

In the practitioner literature, for the years 2008–2010, the most popular tools were the ecosystem service valuation and the life cycle analysis, one valuation-based tool and one measurement-based tool, respectively. For the years 2000–2007, only one study was located for each of the listed tools, making irrelevant any broad assumptions.

Figure 5

TOP TOOLS BY STUDY TYPE AND YEAR GROUPING

	2000–2003	2004–2007	2008–2010
ACADEMIC	**Ecological Footprint (Measurement)**	**Life Cycle Analysis (Measurement)**	**Life Cycle Analysis (Measurement)**
PRACTITIONER	Balanced Scorecard Approach (Measurement)	Ecological Footprint (Measurement)	**Ecosystem Service Valuation (Valuation)**
	Ecological Footprint (Measurement)	Ecosystem Service Valuation (Valuation) Genuine Wealth Accounting Model (Measurement) Life Cycle Analysis (Measurement)	**Life Cycle Analysis (Measurement)**

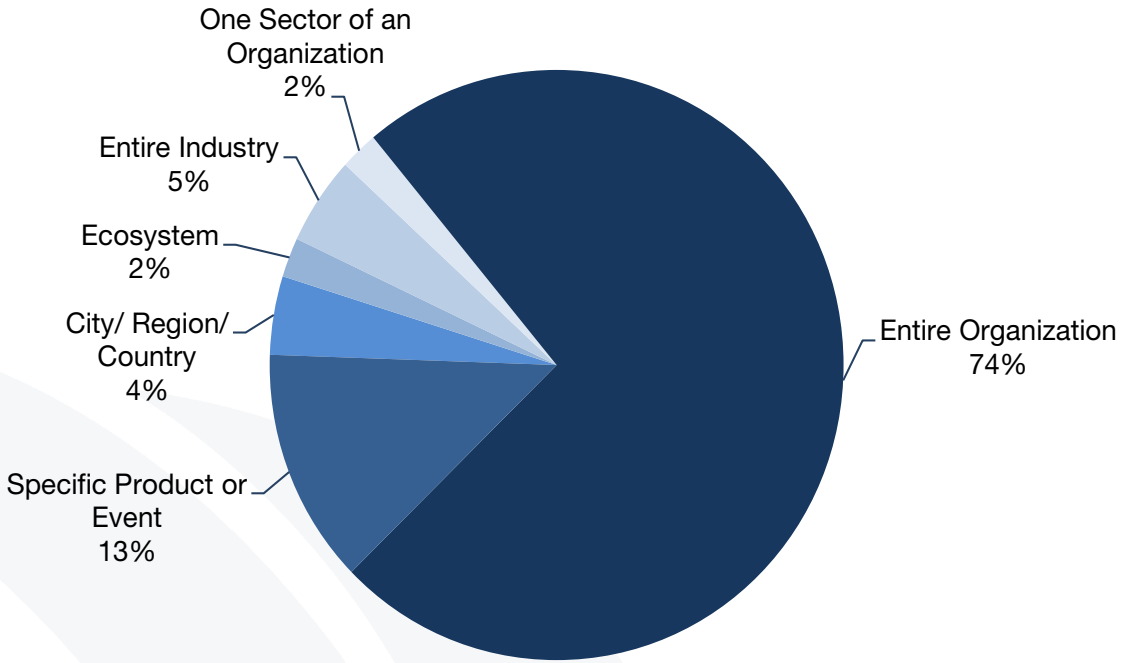
Note that a bolded tool indicates a tool investigated in three or more studies.

LEVELS OF ANALYSIS

In terms of what the studies measured, 74 percent focused on analyzing an entire organization and slightly more than 13 percent focused on analyzing a particular product or event, such as a sporting event or the entire process of bringing a new television to market, from its conceptual design to its disposal after a consumer is finished with it (Figure 6). Only five percent of the studies focused on an entire industry, such as a fishery, while four percent focused on a location, such as a city, region or country. In further subdividing the collected literature by study type (academic or practitioner), no significant differences appeared.

Figure 6

WHAT DID THE STUDIES MEASURE?



POPULARITY OF METHODOLOGIES BY ANALYSIS LEVEL

The data also revealed which tools were studied at each level of analysis. A large proportion of the studies were found to have examined an entire organization, or a specific product or event and, hence, more information was available for these categories (Table 1). When measuring an entire organization's environmental performance, four tools stood out: the balanced scorecard approach, life cycle analysis, environmental management system modelling and the ecological footprint. In terms of the environmental performance of one specific product or event, the life cycle analysis was by far the most commonly studied tool.

The ecological footprint was found to be the most commonly studied tool used to measure the environmental impacts of a city, region or country. To study ecosystems, ecosystem service valuation was found to be most popular. The studies did not appear to have consensus, however, regarding which tools were used more often to measure the impacts of either entire industries or one sector or department of an organization.

Table 1

THE TOOLS USED FOR THE VARIOUS TYPES OF STUDIES

MEASUREMENT-BASED METHODS/TOOLS:	CITY/ REGION/ COUNTRY	ECOSYSTEM	ENTIRE INDUSTRY	ONE SECTOR OF AN ORGANIZATION	ORGANIZATION	SPECIFIC PRODUCT OR EVENT
Balanced Scorecard Approach					******	
Carbon Footprint			*		***	
Destination Environmental Scorecard					*	
Ecological Footprint	***	*		*	****	**
Environmental Evaluation Matrix					*	
Environmental Management System Modelling					*****	*
Epstein Roy Framework					*	
Genuine Wealth Accounting Model					*	
Green Globes Design					*	
Green Productivity Index						*
Life Cycle Analysis				*	********	**********
Lowell Center Hierarchy					*	
Materials Flow Analysis					*	
Responsive Business Scorecard					**	
Whole Life Value						*
VALUATION-BASED METHODS/TOOLS:						
Cost-Benefit Analysis		*			*	
Ecosystem Service Valuation		**	*		**	
Environmental Input-Output Model	*				*	**
Sustainable Value Added					***	
Triple Bottom Line Reporting					**	

Note that the number of asterisks (*) indicates the number of studies that applied a specific tool.

DIFFERENCES BY REGION

The life cycle analysis was commonly studied in three of the four continents that published two or more studies in the database: Asia, Europe, North America and Oceania (Figure 7). The environmental management system model was investigated in studies in both Asia and North America, while the ecological footprint model was investigated in both Europe and North America. Whereas the life cycle analysis, ecological footprint and environmental input-output model were applied in three or more studies in Europe, in the other three continents these tools were investigated in two or fewer studies. Due to the small number of studies published in Asia, North America and Oceania no strong assumptions can be made.

Figure 7

TOP TOOLS BY CONTINENT (with two or more studies)

ASIA	EUROPE	NORTH AMERICA	OCEANIA
Environmental Management System Modelling (Measurement)	**Life Cycle Analysis (Measurement)**	Ecological Footprint (Measurement)	Life Cycle Analysis (Measurement)
	Ecological Footprint (Measurement)	Environmental Management System Modelling (Measurement)	
	Environmental Input-Output Model (Valuation)	Life Cycle Analysis (Measurement)	
	Responsive Business Scorecard (Measurement)		

Items that are in bold were in three or more studies.

DIFFERENCES BY INDUSTRY

Industries were grouped into nine categories: basic materials, consumer goods, financial, health care, industrial goods, services, technology, utilities and an unspecified category that included all studies that did not identify a specific industry (Table 2).

After separating the tools by industry, no one tool appeared to be favoured (Table 3). The two exceptions were the consumer goods and industrial goods sectors, which clearly favoured the life cycle analysis; however, other tools were also studied in those industries.

All other tools appeared in no more than three studies within any specific industry category. A column labelled "unspecified" was created for those studies that did not identify a specific industrial sector. In this category, the balanced scorecard, ecological footprint, ecosystem service valuation and life cycle analysis appeared in three or more studies.

Table 2

INDUSTRY CATEGORIES USED TO GROUP THE DATA[4]

BASIC MATERIALS	CONSUMER GOODS	FINANCIAL	HEALTH CARE	INDUSTRIAL GOODS	SERVICES	TECHNOLOGY	UTILITIES
Chemicals	Automotive	Banking	Drugs	Aerospace and Defence	Diversified Services	Computer Hardware	Utilities
Energy	Consumer Durables	Financial Services	Health Services	Manufacturing	Leisure	Computer Software	
Metals and Mining	Consumer Non-Durables	Insurance		Materials and Construction	Media	Electronics	
	Food and Beverage	Real Estate			Retail	Internet	
					Specialty Retail	Tele-communications	
					Transportation		
					Wholesale		

Note: An unspecified category was added to include all those studies that did not identify a specific industry.

[4] Industry categories were created after extensively reviewing the categorizations on several websites, including http://www2.standardandpoors.com/spf/pdf/index/GICS_methodology.pdf, http://www.census.gov/eos/www/naics/ and http://stockmaven.com/sectorsTSPG.htm.

Table 3

TOOLS USED IN THE DATABASE STUDIES BY INDUSTRY CATEGORY

MEASUREMENT-BASED METHODS/TOOLS:	BASIC MATERIALS	CONSUMER GOODS	FINANCIAL	HEALTH CARE	INDUSTRIAL GOODS	SERVICES	TECHNOLOGY	UNSPECIFIED	UTILITIES
Balanced Scorecard Approach						*		*****	
Carbon Footprint		**			*	*			
Destination Environmental Scorecard						*			
Ecological Footprint	*	*			*	***		****	*
Environmental Evaluation Matrix					*				
Environmental Management System Modelling					**	**		**	
Epstein Roy Framework								*	
Genuine Wealth Accounting Model								*	
Green Globes Design						*			
Green Productivity Index					*				
Life Cycle Analysis		****			*****	***	**	******	
Lowell Center Hierarchy				*					
Materials Flow Analysis		*							
Responsive Business Scorecard		**							
Whole Life Value					*				
VALUATION-BASED METHODS/TOOLS:									
Cost-Benefit Analysis			*					*	
Ecosystem Service Valuation		*						****	
Environmental Input-Output Model						**	*	**	
Sustainable Value Added					*	*		*	
Triple Bottom Line Reporting		*						*	

Note that the number of asterisks (*) indicates the number of studies that applied a specific tool.

a closer look at two measurement tools

The Ecological Footprint measures the area of ecologically productive land and sea required to support human resource demands. A Life Cycle Analysis compares all social and environmental damages related to a product or service.

In this section, two measurement tools are examined in detail: the ecological footprint and life cycle analysis. The ecological footprint was selected because it forms the basis for several other commonly used tools, including the carbon footprint and the water footprint. The life cycle analysis tool was the most commonly studied measurement tool in the database and, as such, we believe it is significant to report on in more detail. All other identified tools are listed and described briefly in Appendix C.

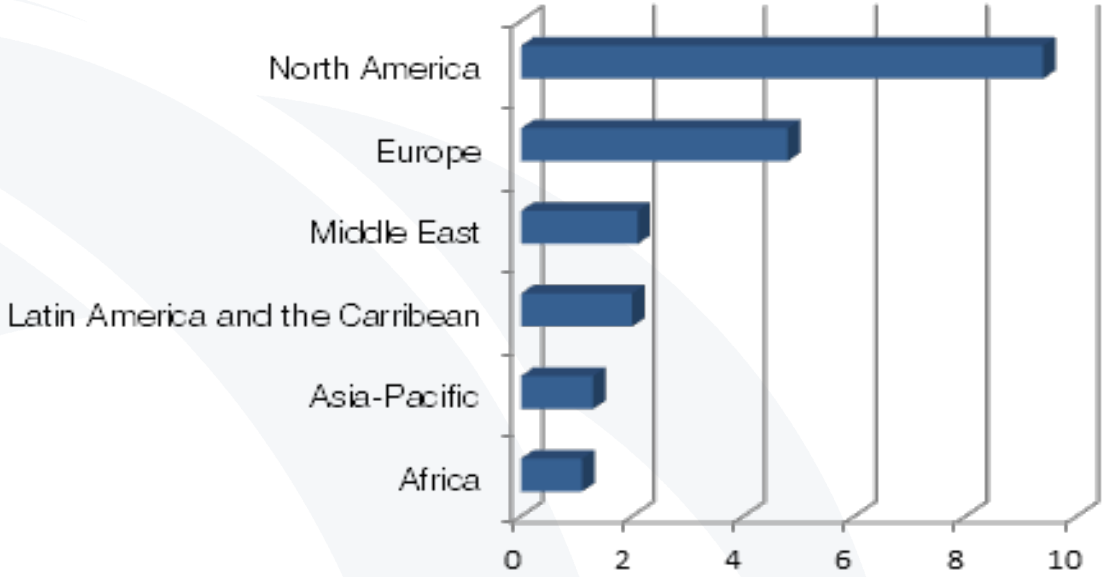
Ecological Footprint

OVERVIEW

The ecological footprint, also called the environmental footprint and the eco-footprint, is a physical measurement indicator focused on measuring the area of ecologically productive land and sea required to support human resource demands, such as food, energy and housing in addition to the assimilation of wastes. The concept and calculation method for the ecological footprint was created in the 1990s by Professor William Rees and PhD student Mathis Wackernagel as a dissertation at the University of British Columbia in Vancouver, Canada (Wackernagel, 1994).

Figure 8

ECOLOGICAL FOOTPRINT BY REGION IN 2003



The ecological footprint indicator is typically measured in hectares or acres. It can be calculated for a person or firm, or for a local, regional, national or global area. Ideally, to be sustainable, according to the ecological footprint calculation, each person should use one global hectare or less annually. Figure 8 illustrates that on average in 2003, people used more resources than the earth could provide. Much advancement has been made in calculating ecological footprints since the seminal work by Wackernagel (1994). One significant advancement is in the creation of Footprint 2.0 by Redefining Progress, a U.S.-based non-profit organization (when Footprint 2.0 came to fruition, the Wackernagel Model became known to some as Footprint 1.0.). Footprint 2.0 suggested conducting calculations that are based on the entire surface of the earth in biocapacity, reserving a portion of the earth's productive resources for non-human species, calculating carbon sequestration rates in a more advanced manner and using net primary productivity for comparisons (Venetoulis and Talberth, 2009).

Overall, the ecological footprint focuses on measuring environmental aspects; as such, it does not consider economic or social aspects. Therefore, companies that focus on all three aspects of sustainability (i.e. economic, social and environmental) should calculate their ecological footprint alongside other sustainability indicators.

ADVANTAGES

- The ecological footprint calculation results in one number (in hectares or acres) that can be easily compared with other footprint calculations, whether at an individual, firm, local, regional, national or global level. Such comparisons can be useful for benchmarking across similar facilities or country operations (possibly normalizing the footprint per unit of production).
- The ecological footprint calculation can be used to complement other sustainability calculations, such as economic and social calculations. As such, the footprint calculation could form one section in a sustainability report.

DISADVANTAGES

- Critics argue that aggregating the calculation of the ecological footprint into one number (in global hectares or global acres) oversimplifies diverse and complex environmental impacts.
- Because the ecological footprint focuses specifically on the number of hectares or acres required to support human resource demands, its calculations can place a higher value on some locations that might otherwise be valued less highly. For example, a productive mono-cultural agricultural crop can be valued higher than an ancient native forest or an organic crop that has a lower yield.
- The ecological footprint may identify densely populated cities as being more parasitic than rural areas because of their strong reliance on the surrounding lands for their resources.
- Despite the ecological footprint being applicable to all firms, some managers may not believe this method is relevant to their business because the calculations are based on farm, logging and seafood businesses.

CALCULATING AN ENVIRONMENTAL FOOTPRINT

In October 2010, the Global Footprint Network published a document detailing the data and formulas that can be used to calculate the environmental footprint (Ewing et al., 2010), available online at: www.footprintnetwork.org/images/uploads/National_Footprint_Accounts_Method_Paper_2010.pdf.

More specifically, for an organization, the data required to calculate the footprint can include the following:

- Cropland area required to produce the crops
- Grazing land area required to produce animal products
- Forest area required to produce wood and paper products
- Ocean area required to produce seafood
- Land area required for housing and infrastructure
- Forest area required to absorb carbon dioxide emissions (Barrett and Scott, 2001; Collins et al., 2007; Dietz et al., 2007; Global Footprint Network, 2009; Knaus et al., 2006; Loh, 2003; Venetoulis and Talberth, 2009; Wackernagel, 1994)

WHY SHOULD MANAGERS CARE ABOUT THIS METHOD?

The ecological footprint has been around since the 1990s; as such, many newer tools, such as the water footprint and the carbon footprint, are based on its methodology. Because this method is older than the others and has been the focus of many studies, a great deal of information currently exists to base calculations.

The ecological footprint was the most frequently studied tool during 2000–2003 and the second most frequently studied tool during the 2008–2010 period. Many researchers may favour this tool because it results in one number, in global hectares or acres, which indicates environmental impacts. While many researchers use this value to compare countries, regions or cities around the world, a multi-site organization can use the tool to compare its ecological footprint in one location with its ecological footprint in all its other locations. Consequently, the ecological footprint is recommended for organizations that have operations in a variety of locations. Comparisons should be based, however, on locations with similar operations, as a gold mining operation is likely to have more (and different) effects on the environment than a design office. This tool can also be used to compare footprints between years.

Life Cycle Analysis

OVERVIEW

The life cycle analysis, also called the life cycle assessment and the simplified life cycle analysis, was found to be the most commonly studied technique in the study's database. The first life cycle analysis was conducted in 1969 by the Coca-Cola Company to determine which of a variety of beverage containers had the smallest effect on the environment. Not long afterward, in the early 1970s, other companies in the United States and Europe began conducting life cycle analyses on their products and services (Scientific Applications International Corporation, 2006). The data from this study revealed an increase in the popularity of studies investigating the life cycle analysis method over the past 10 years. The life cycle approach can help firms make informed choices by considering all links in the life cycle chain, including those outside the direct purview of the company.

Table 4

ECOLOGICAL FOOTPRINT DATABASE STATISTICS

AREAS THAT USED IT	YEARS USED	REGIONS THAT STUDIED THE METHOD	INDUSTRIES THAT STUDIED THE METHOD	PERCENT OF STUDIES IN THE DATABASE THAT USED THE METHOD
City/Region/Country Studies	**#1 Method during the 2000–2003 Period**	**Europe**	**Services**	**15%**
Entire Organization Studies	Not in the top 3 most popular methods during the 2004–2007 period	North America	**Unspecified**	
Ecosystem Studies	**#2 Method during the 2008–2010 Period**		Basic Materials	
One Sector or Department in an Organization Studies			Consumer Goods	

Note that a bolded entry indicates the tool was investigated in three or more studies

A life cycle analysis follows a product or service throughout its entire life cycle, from raw material acquisition to manufacturing, production, use, reuse, maintenance and waste management. Conducting a life cycle analysis follows four basic steps:

1. Scope and goal definition
2. Inventory analysis
3. Impact assessment
4. Interpretation of results

A life cycle analysis enables the comparison of all possible social and environmental damages related to the product or service under review. Some of the damage categories assessed in a life cycle analysis include greenhouse gases, soil acidification, water pollution, ozone depletion and habitat destruction. Once an analysis is complete, this information can then be used to select the least ecologically, or least socially, burdensome of the analyzed products or services.

A life cycle analysis is only as good as its data. Thus, the use of current data is essential. For example, phone and computer products change so frequently that a life cycle analysis for these products might need to be updated every few months for the results to remain relevant.

According to a United States Environmental Protection Agency website on life cycle analyses (www.epa.gov/nrmrl/lcaccess/resources.html), more than 30 organizations have created software packages for conducting life cycle analyses. Many of the software packages are available on these organizations' websites; some software packages are available free and others require a fee[5]. Life cycle analysis procedures are also part of the International Organization for Standardization ISO 14000 environmental standards (www.iso.org/iso/home.html).

[5]The mention of these various software tools and databases does not indicate any endorsement by the author.

Some consider a simplified life cycle analysis to be a more realistic type of life cycle analysis because it addresses only the aspects directly related to a product, not the more abstract concepts. For example, consider a company that sells apple sauce. While an ideal assessment may review the entire apple-growing process from obtaining seeds or rootstock through the entire cultivation process, such a wide view may not be practical because the entire process of creating the seeds and grafting the plants or rootstock may have taken decades to achieve. Instead, the company might choose to consider only the resources used to produce apples for one particular year or only the process of picking and transporting the apples for processing. In this way, most life cycle analyses are simplified life cycle analyses because, although they consider a large portion of a process, considering the entire process may not be practical.

A related tool, materials flow analysis, also known as substance flow analysis, is used in industrial ecology to study the linkages between society and the environment. This method analyzes both the flow of a material through an industry or firm and the effect on ecosystems. The scope of materials flow analysis can be a national scale, a regional scale, a corporate or industrial scale or the life cycle of a product. Thus, materials flow analysis is directly comparable to a life cycle analysis (Hobbes et al., 2007).

ADVANTAGES

- Once a firm has constructed a life cycle analysis model (e.g. by placing all relevant data into a related software package), conducting new or accelerated life cycle analyses is much easier, as is comparing these analyses for a variety of products or services.
- Life cycle analysis helps a firm to make choices and to analyze important external factors (e.g. political, economic, technological and social).
- Many software packages are available to assist a company in conducting a life cycle analysis. Some software packages are available at very little or no cost to the user.
- Although many life cycle analyses do not include economic values, a tool is available that combines input-output analysis (an economic concept) with the life cycle analysis (a non-monetary concept): the EIO-LCA (Environmental Input-Output Life Cycle Analysis). More information about this tool is available at: www.eiolca.net.
- Because of the popularity of the tool, extensive information is available to assist firms in conducting a life cycle analysis, from inventory data to assessment information and assessment tools. Many organizations are also available to assist firms with the entire process, possibly simplifying the application process.
- Another good information resource is a journal dedicated to life cycle analysis, the International Journal of Life Cycle Assessment.

DISADVANTAGES

- When a product or service is being analyzed from its beginning to its disposal, a company may face difficulties obtaining data for the product prior to when they obtained the required materials, as well as after it leaves their hands and the consumer either disposes of it or recycles it. Again the analysis is only as good as the data.
- Not all life cycle analyses are calculated in the same manner. This lack of uniformity makes it difficult to compare results across two or more life cycle analysis studies. Although some critics see this lack of uniformity as a disadvantage, it may be reasonable given that each product or service is created in a very different manner.

CALCULATING A LIFE CYCLE ANALYSIS

For more information on the basics of life cycle analysis and on conducting or on managing a life cycle analysis, please refer to this guide hosted on the U.S. Environmental Protection Agency's website: www.epa.gov/nrmrl/lcaccess/pdfs/600r06060.pdf (Scientific Applications International Corporation, 2006).

WHY SHOULD MANAGERS CARE ABOUT THIS METHOD?

The life cycle analysis was first used in the late 1960s and has experienced an increase in popularity between 2000 and 2010. Because of this popularity and the tool's inclusion in the International Organization for Standardization environmental standards, organizations will find that useful information is available on the life cycle analysis. In addition to online guidelines and a journal, firms have access to more than 30 computer applications, many of which are free. The life cycle assessment has been well studied in Europe, North America and Oceania. Although life cycle analyses have been conducted in many ways, they appear to be most commonly applied to new products or when assessing a specific event.

Table 5

LIFE CYCLE ANALYSIS DATABASE STATISTICS

AREAS THAT USED IT	YEARS USED	REGIONS THAT STUDIED THE METHOD	INDUSTRIES THAT STUDIED THE METHOD	PERCENT OF STUDIES IN DATABASE THAT USED THE METHOD
Entire Organization Studies	**#2 Method during the 2000–2003 Period**	**Europe**	**Consumer Goods**	**27%**
Specific Product or Event Studies	**#1 Method during the 2004–2007 Period**	North America	**Industrial Goods**	
One Sector or Department in an Organization Studies	**#1 Method during the 2008–2010 Period**	Oceania	**Services**	
			Unspecified	
			Technology	

Note that a bolded entry indicates the tool was investigated in three or more studies

Ecosystem Service Valuation assigns a dollar value to the soil, trees, insects, seeds, rivers, etc. that provide recreation for humans and habitat for animals. The Environmental Input-Output model describes an organization's flow of goods and services including their environmental effects.

In this section, two valuation tools are examined in detail: ecosystem service valuation and input-output analysis. Ecosystem service valuation was chosen because it appears to be an up-and-coming tool that has increased in popularity over the past few years. Input-output analysis was selected because it began as a tool to focus on non-environmental benefits and costs, and has since evolved to include environmental aspects. All other identified tools are listed and described briefly in Appendix C.

Ecosystem Service Valuation

OVERVIEW

Ecosystem services are those services that contribute directly to life, such as the dispersal of seeds for flora reproduction or a conservation area that supplies both recreation to humans and a habitat for animals. According to Kaval (2010), ecosystem services comprise approximately 22 categories (Table 6). Ecosystem service valuation is the process of placing values on the ecosystem services in an area of concern and determining how the values and ecosystem services will change as a consequence of a project, such as the construction of a new building or the clearing of land to plant agricultural crops.

The process of valuing ecosystem services is complicated and can range from a simple calculation of the price of gold to determining more complicated values, such as the value of bees pollinating crops (Merlo and Croitoru, 2005; Pearce and Turner, 1990). Calculating all ecosystem service values will yield a total economic value, or a flow of all benefits and costs provided by the ecosystem. This total economic value is a complete analysis because it considers all use values, or the value of actually using a resource in a particular way (e.g. fishing), in addition to all non-use or indirect values, when a resource is not used directly but is still a benefit (e.g. the value of worms churning the soil of crops) (Costanza et al., 1997; Daily, 1997; Daily et al., 1997; De Groot et al., 2002; Eftec, 2006; Kaval, 2010).

Table 6

ECOSYSTEM SERVICE CATEGORIES

22 ECOSYSTEM SERVICE CATEGORIES
Aesthetic beauty
Biodiversity maintenance
Detoxification and decomposition of wastes
Erosion control
Food production
Genetic and medicinal resources
Human culture
Natural disturbance regulation
Natural pest and biological control
Nursery function
Nutrient cycling
Partial climate stabilization
Plant and animal refugia
Plant pollination
Preservation (including existence, bequest and option value
Protection from sun's ultraviolet rays
Purification and regulation of air and water
Raw materials
Recreation
Science and education
Seed dispersal
Soil formation

Source: Kaval, P. 2010. A Summary of Ecosystem Service Economic Valuation Methods and Recommendations for Future Studies. University of Waikato, Hamilton, New Zealand.

Ecosystem service valuation methods can be categorized into two general groups: market values and non-market values. Market values are the out-of-pocket expenses traded in formal markets, such as the sale of fish that were caught or the cost of a monthly electric bill. Non-market values are not as easy to calculate; however, several tools are available to calculate these values, including the travel cost method, the hedonic pricing method, the contingent valuation method, the choice modelling method, the avoided cost method, the restoration cost method, the replacement cost method, the factor income method and the benefit transfer method. A very brief description and example of each is presented in Table 7.

Table 7

ECOSYSTEM SERVICE VALUATION METHODS WITH BRIEF DESCRIPTIONS AND EXAMPLES

VALUATION METHOD	BRIEF DESCRIPTION	BRIEF EXAMPLE
Market valuation method	Value of goods and services traded on the public market	The cost of one month of electricity for your company, where a monetary exchange took place.
Travel cost, or Clawson, method	Value to attend a specific event or place	Costs of attending a meeting in another town instead of staying at the office; this value can include the cost of a plane ticket, meeting fees, rental car, fuel, meals and lodging.
Hedonic pricing method	Value of an environmental amenity, typically in relation to a house, building, or property price	If you believe your employees will work harder if they have a view of the ocean, this value could be the difference between the value of purchasing a building with an ocean view and the value of an identical building in the same general area but without an ocean view.
Contingent valuation method	Value of a hypothetical change in a product or service when presented with one scenario	Would you be willing to pay $15 annually from your paycheque in exchange for a maintained five-kilometre nature trail and two picnic tables next to your office building?
Choice modelling method	Value of a hypothetical change in a product or service when presented with several scenarios, where each scenario comprises several attributes	Would you be willing to pay: Option 1: $15 annually from your paycheque in exchange for a maintained five-kilometre nature trail, two picnic tables and one toilet next to your office building? Option 2: $20 annually from your paycheque in exchange for a maintained six-km nature trail, one picnic table and no toilets next to your office building? Option 3: No cost, no nature trail, no picnic tables and no toilet (i.e., status quo)?
Avoided costs method	Value of ecosystem services that you avoid paying for because a service is being provided by the ecosystem	The sun currently provides us with vitamin D. If the sun stopped shining on the community where you live, you would need to pay for vitamin D supplements. The cost of the vitamin D supplements is the avoided cost.
Restoration costs method	Value of an ecosystem service that restores an ecosystem to its natural state after a disturbance	If you were to crash your car off the road and some oil spilled into the river, the river may be able to dilute the oil so it dissipates and avoids harming the river in any significant way. If the spill was too large to dissipate and the oil had a detrimental effect on the river or surrounding area, the restoration cost would be the cost to restore the river to its natural state (prior to the spill).
Replacement costs method	Value of not having to pay for a man-made product to produce a needed service that is currently supplied by the ecosystem	Plants produce oxygen that we need to breathe. If we lacked natural oxygen producers, such as plants, we would need to use a human-made, oxygen-producing device to live and breathe. The cost of that device is the replacement cost.
Factor income method	Value of an ecosystem service that enhances the market value of other ecosystem services	Crops may produce more (or larger) fruit when they are pollinated by bees. Factor income is the difference between the value of the fruit if the plants were not pollinated by bees and the value of the fruit if they were pollinated.
Benefit transfer method	Valuing an ecosystem service by transferring results from one study to another; conducted if the time and/or funding are not available to conduct an original study	If you wanted to estimate the value of a specific lobster fishery in one cove, but did not have the time or funding to collect your own original data, you could use the results of another study in a similar area with a similar situation to represent what you believe are valid data for your study.

Source: Kaval, P. 2010. A Summary of Ecosystem Service Economic Valuation Methods and Recommendations for Future Studies. University of Waikato, Hamilton, New Zealand and Riera, P., G. Signorello, M. Thiene, P.A. Mahieu, S. Navrud, P. Kaval et al., 2010. Good practice issues on non-market valuation of forest goods and services

The valuation methods applied will depend on the ecosystem service types relevant to the project being studied. Many different methods can work for any given service, and the method of choice depends on the project goals and availability of resources, funding and time.

ADVANTAGES

- If a complete ecosystem service valuation is conducted, it will be an extremely thorough valuation, possibly providing the most in-depth perspective possible.
- Ecosystem service valuations provide extensive information for an organization when it is considering the construction of a building, restoring an area (such as returning as a former mine to its original condition) or another land use change.
- Easy for extractive industries to visualize and calculate their impacts.

DISADVANTAGES

- Conducting a complete ecosystem service valuation is an extensive process; much time and many resources are required, and the process can be expensive. A firm may thus choose to focus only on the ecosystem services of greatest interest.
- Because each ecosystem service can be valued in many ways, researchers use different techniques to value the different ecosystem services. As a result, comparisons between studies are not always possible.

CALCULATING AN ECOSYSTEM SERVICE VALUATION STUDY

Two studies may be helpful for organizations interested in conducting an ecosystem service valuation study: Kaval (2010) and Riera et al. (2011). The Kaval study (http://ideas.repec.org/p/wai/econwp/10-02.html) provides step-by-step instructions for conducting an ecosystem service valuation. The Riera et al. (2011) publication focuses on extensive details of the various valuation methods, such as calculating a contingent valuation study.

WHY SHOULD MANAGERS CARE ABOUT THIS METHOD?

Ecosystem service valuation is an up-and-coming technique that is gaining attention. It is most easily conceptualized when an organization plans to modify a piece of land in some way, such as by converting a forested area into a mine or by constructing a new building; once the mine has been excavated or the building constructed, it may not be possible to determine the original ecosystem prior to the land change. This tool is also helpful when the organization is attempting to restore an area to a condition closer to its original condition. Because ecosystem service valuation is such a new tool, the manager or researcher needs to determine which aspects and values to focus on. Once a complete ecosystem service valuation has been conducted, applying the same procedure to new sites will be easier because the tools will already be in place.

Because ecosystem service valuation requires extensive documentation of all environmental effects, managers may find it useful for building an evidence-based defence in the case of environmental litigation and for studying the impact of new environmental regulations that may require changes in company operating procedures.

Table 8

ECOSYSTEM SERVICE VALUATION DATABASE STATISTICS

AREAS THAT USED IT	YEARS USED	REGIONS THAT HAVE STUDIED THE METHOD	INDUSTRIES THAT HAVE STUDIED THE METHOD	PERCENT OF STUDIES IN THE DATABASE THAT USED THIS METHOD
Ecosystem Studies	Not in the Top 3 most popular methods during 2000–2003	Not popular in any specific region	**Unspecified**	**7%**
Entire Industry Studies	Not in the Top 3 most popular methods during 2004–2007		Consumer Goods	
Entire Organization Studies	**#3 Method during 2008–2010**			

Note that a bolded entry indicates the tool was investigated in three or more studies

Environmental Input-Output Model

OVERVIEW

An environmental input-output model is an economic tool that can be used to describe an organization's flow of goods and services, including their environmental effects. This tool also demonstrates how organizations are linked together, because organizations use the products and/or services from other organizations to produce their own goods and/or services. The input-output model was introduced by Wassily Leontief in 1951 (Leontief, 1951).

The environmental input-output model for an organization demonstrates the relationship between different departments, divisions or companies within the organization, in addition to the relationship the organization has with other organizations. Put very simply, the input-output model is based on the following equation: Production – Consumption = Demand. Numbers that correspond to the inputs and outputs, in relation to production and consumption, are entered into a matrix, which illustrates how outputs change when inputs change or, more specifically, how profits change when demand and/or the costs of inputs (including the costs of environmental pollution) change.

An input-output model has two basic players: the producers and the consumers and/or users. The producers create products. For example, an administrative department both hires employees for the manufacturing department and markets the product the manufacturing department produces; the raw material supplier sells raw materials to the manufacturing department for use in its product development; and the office supplier provides the administrative department with the tools it requires, such as paper, copy machines, pens and computers. The consumers and users not only include the people who purchase and use the final products but also other users, such as the staff in the administrative department who use the computers they obtained from the office supplier and the employees of the manufacturing department who use the raw materials they obtained from the raw material supplier to produce the final goods.

A very simplified input-output model for the production and sales of 50,000 widgets is presented in Table 9. In this example, we see that Company A has two departments: an administrative department and a manufacturing department. The administrative department purchases supplies from the office supplier and the manufacturing department purchases raw materials from the raw material supplier. The two suppliers and the manufacturing department cause environmental pollution and directly pay the government or another organization to clean up the pollution. Suppose that demand is high and all widgets produced are sold. Consumers pay $2,500,000 for the purchase of the 50,000 widgets. The total environmental pollution cost of producing the widgets is $69,000, and the total of all other costs is $706,000. Overall profits are $1.7 million. If the organization were to eliminate environmental pollution costs, its profits would increase to approximately $1.8 million, which represents a significant increase.

Although Company A may find it easier to control its own environmental pollution than that of its suppliers, they may have more influence over the environmental pollution of its suppliers if it is a large purchaser of the suppliers' products. For example, if Company A's purchasing represents 80 percent of the raw material supplier's business and they asked the supplier to reduce its pollution or they would stop purchasing its product, the raw material supplier may be motivated to reduce its pollution. However, if Company A's purchasing represented only 0.01 percent of the raw materials supplier's business, that same ultimatum may not be sufficient motivation for the raw material supplier to reduce its pollution (Collins et al., 2007; Gay et al., 2005; Wiedmann et al., 2007).

Input-output models are not only applicable to organizations but can also assist in calculating a nation's gross domestic product, which measures a country's overall economic output and the market value of its goods and services over one year.

Table 9

A SIMPLE INPUT-OUTPUT MODEL REPRESENTING THE PRODUCTION AND SALES OF 50,000 WIDGETS

	CONSUMING OR USING SECTORS							
	ADMINISTRATIVE DEPARTMENT	MANUFACTURING DEPARTMENT	TOTAL OF GOODS	NON-ENVIRONMENTAL POLLUTION COSTS	ENVIRONMENTAL POLLUTION COSTS	COST TOTAL	INCOME TOTAL	PROFITS
Producing sectors								
Administrative department total	$2,000			$2,000		$2,000		
Utilities	$2,000		$2,500,000				$2,500,000	
Manufacturing department income								
Manufacturing department costs		$27,000		$6,000	$21,000	$27,000		
Environmental pollution costs		$21,000						
Utilities		$6,000						
Supplier of raw materials total		$237,000		$200,000	$37,000	$237,000		
Supplies		$200,000						
Environmental pollution costs		$37,000						
Supplier of office supplies total	$39,000			$28,000	$11,000	$39,000		
Supplies	$28,000							
Environmental pollution costs	$11,000							
Non-wage non-environmental pollution costs	$30,000	$206,000		$236,000		$236,000		
Environmental pollution costs	$11,0000	$58,000			$69,000	$69,000		
Wages	$150,000	$320,000		$470,000		$470,000		
Cost total	$191,000	$584,000		$706,000	$69,000	$775,000		
Gross income			$2,500,000				$2,500,000	
Profits								$1,725,000

Note that this table is a simplified example, and an actual input-output table would include many more variables than are presented here. In addition, this table's data are based on the assumption that any environmental pollution costs are being paid for upfront.

CALCULATING AN ENVIRONMENTAL INPUT-OUTPUT MODEL

Conway-Schempf (1999) conducted a detailed report elaborating on how an organization can conduct an input-output study (Conway-Schempf, 1999). This study is available online at: www.ce.cmu.edu/GreenDesign/gd/education/Eio.pdf. The United Nations System of National Accounts also provides a detailed explanation on calculating input-output analysis in its Handbook of National Accounting: Integrated Environmental and Economic Accounting 2003 (http://unstats.un.org/unsd/envaccounting/seea.asp).

WHY SHOULD MANAGERS CARE ABOUT THIS METHOD?

An organization wanting to create an environmental input-output model would essentially create a spreadsheet of all the project's benefits and costs, in addition to outlining the effects to the entire system if one of the benefits or costs were to change. In the example of producing 10,000 more widgets, the spreadsheet could include the benefits of selling more and the administrative, manufacturing and environmental costs of producing more. This particular tool can be applied to any output, including a product or a service. Many resources are available to instruct new users in calculating an input-output analysis, simplifying the process for firms attempting to apply it. However, if an extremely detailed input-output analysis is necessary, experts may be needed to assist in matrix creation. Once the matrix is created however, the process is again simplified for the manager.

ADVANTAGES

- Input-output analysis illustrates all of an organization's activity and the effects on profits, outputs and environmental pollution as various inputs change.
- The basic mathematical calculations for an input-output table are straightforward and easy to understand. That being said, for an extremely complicated input-output table an expert may be needed to create the matrix, but once it is created, the process is again simple for the manager as they will just enter numbers into the matrix and the rest will be automatically calculated.
- The United Nations has created a System of National Accounts to help countries to collect data for input-output analysis and as a result, enable easier international comparisons.
- Input-output models have extensive analytical power.
- Input-output models present an extensive amount of data in an easy-to-understand and orderly fashion.

DISADVANTAGES

- An input-output model requires extensive data because all costs and benefits for every economic activity must be represented.
- Many organizations may not maintain records of all the data required. In addition, data quality may vary.
- An organization may face difficulties obtaining data from all departments, divisions or companies.
- An organization may face difficulties obtaining data from other organizations they are involved with, especially in relation to environmental pollution.
- Because of the extensive data requirements, experts may be needed to create the matrices.
- Because technology, demand and prices are constantly changing, to ensure accuracy data need to be updated constantly.
- Input-output models make the general assumption that a firm has one production function and produces one product, which is typically not the case.

Table 10

ENVIRONMENTAL INPUT-OUTPUT MODEL DATABASE STATISTICS

AREAS THAT USED IT	YEARS USED	REGIONS THAT HAVE STUDIED THE METHOD	INDUSTRIES THAT HAVE STUDIED THE METHOD	PERCENT OF STUDIES IN THE DATABASE THAT USED THIS METHOD
City/ Region/ Country Studies	Not in the Top 3 most popular methods during 2000–2003	**Europe**	Services	**7%**
Entire Organization Studies	**#3 Method during 2004–2007**		Technology	
Specific Product or Event Studies	Not in the Top 3 most popular methods during 2008–2010		Unspecified	

Note that a bolded entry indicates the tool was present in three or more studies.

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appendix A

Detailed Description of the Search Process

SYSTEMATIC REVIEW METHODOLOGY

A systematic review was conducted to provide a clear understanding of the current knowledge in measuring and valuing a firm's environmental/ecological impact. Two general categories of literature were included in the database:

1. Academic Peer-Reviewed Literature
2. Practitioner Literature

A three-step process for the Academic Peer-Reviewed Literature and the Practitioner Literature was followed to ensure a transparent, replicable and scientific product:

1. Search Process:
   a) Inventory existing documents focused on measuring and/or valuing a firm's environmental/ecological impacts. Download document citations, including abstracts, into an Endnote file.
   b) Screening Process:
      i) Initial screening of retrieved documents.
         (1) Delete duplicate references.
         (2) Screen title and abstract of retrieved documents for relevancy to measuring and/or valuing a firm's environmental/ecological impacts. Delete irrelevant documents from Endnote file.
      ii) Secondary screening of retrieved documents.
         (1) Download full copies of all potentially relevant documents.
         (2) Review all potentially relevant documents in detail. Delete irrelevant documents from the Endnote file.
2. Data Synthesis:
   a) Create a master coding sheet for the Excel database.
   b) Synthesize data from all relevant documents into the Excel database.
3. Systematic Review:
   a) Create tables and figures from the completed data table.
   b) Analyze the completed data table for patterns in the data.
   c) Write systematic review report based on gathered information.

Academic Peer-Reviewed Literature Search 1

SEARCH PROCESS

Inventory existing documents focused on measuring and/or valuing a firm's environmental/ecological impacts. Download document citations, including abstracts, into an Endnote file.

Initial search strategy to inventory existing Academic Peer-Reviewed Literature documents focused on measuring and/or valuing a firm's environmental/ecological impacts

The first academic literature search process was conducted in January and February of 2010.

To obtain any new and unpublished relevant reports, two listservs were contacted in January 2010. Listserv contributors were asked whether they had written any new and unpublished relevant reports related to measuring and valuing a firm's environmental/ecological impact.

Two listservs were contacted:

- ResEcon - Land & Resource Economics Network listserv - a listserv for environmental and resource economists.
- ONE - Academy of Management Organization and Natural Environment listserv - a listserv for people interested in the relationships between organizations and the natural environment.

The next step in the systematic review process was to search the relevant databases. As the purpose of this project was to measure and value a firm's environmental/ecological impacts, search terms were based on the words relevant to the purpose of the project, including measure, measuring, value, valuing, valuation, firm, business, "environmental impact," "ecological impact" and "ecological footprint." Searching on the terms alone produced a significant number of irrelevant sources, as did searches including the terms "measure," "value," "valuing" and "ecological footprint." As a result, search terms were modified to include those terms that resulted in the largest number of seemingly relevant documents.

Relevant searches were found for the following keyword combinations:

- measuring AND firm AND "environmental impact"
- measuring AND business AND "environmental impact"
- measuring AND firm AND "ecological impact"
- measuring AND business AND "ecological impact"
- measuring AND firm AND "environmental impact"
- measuring AND business AND "environmental impact"
- valuation AND firm AND "environmental impact"
- valuation AND business AND "environmental impact"
- valuation AND firm AND "ecological impact"
- valuation AND business AND "ecological impact"
- valuation AND firm AND "environmental impact"
- valuation AND business AND "environmental impact"

As a result, the final search term used in this study was:

- (measuring OR valuation) AND (firm OR business) AND ("environmental impact" OR "ecological impact")

This search string significantly increased the number of relevant studies and consequently decreased the number of irrelevant studies, but still resulted in thousands of studies. After a conference call in January 2010 with the Network for Business Sustainability Oversight Committee, it was agreed that the search should focus on studies published during the past decade. Because some of the database search engines did not allow specific date searches (only years and not exact days), the final search included studies from January 1, 2000, to the present.

Searched databases included the following:

- ProQuest – All of ProQuest, including, but not limited to:
- ABI/Inform Trade & Industry
- CBCA Business
- ERIC
- ProQuest Asian Business and Reference
- ProQuest European Business
- ProQuest Science Journals
- ProQuest Social Science Journals
- Wiley Interscience
- JSTOR
- EconLit
- ISI Web of Knowledge – All of ISI Web of Knowledge, including, but not limited to:
- Science Citation Index Expanded
- Social Sciences Citation Index
- Arts & Humanities Citation Index
- Conference Proceedings Citation Index – Science
- Conference Proceedings Citation Index – Social Science and Humanities
- EBSCOhost: Business Source Premier

Specialized online sources included:

- GLOBE-Net
- Greenbiz.com
- SocialFunds.com
- CSRwire
- United Nations Environment Programme Finance Initiative (UNEPFI)
- World Business Council for Sustainable Development
- Network for Business Sustainability website
- RePEc – Research Papers in Economics
- Global Reporting Initiative
- Google Scholar Advanced
- SSRN – Social Science Research Network

In total, 904 potential papers were identified. The citations, including the abstracts, of these papers were downloaded into an Endnote file. Initial screening of retrieved documents:

- Delete duplicate references.
- Screen title and abstract of retrieved documents for relevancy to measuring and/or valuing a firm's environmental/ ecological impacts. Delete irrelevant documents from Endnote file.

During the initial screening, duplicate references were removed. For a few of the studies, the same reference appeared from two to five times in the Endnote file.

After duplicate references were removed, search results were scrutinized individually for relevance, as determined by the titles and abstracts.

From the original 904 studies identified, 152 were deemed as potentially relevant studies.

Secondary screening of retrieved documents:

- Download full copies of all potentially relevant documents.
- Review all potentially relevant documents in detail. Delete irrelevant documents from the Endnote file.

During the first part of the secondary screening process, full-text copies were obtained of all 152 potentially relevant studies. Most studies were downloaded from the Internet. Those studies not available on the Internet were obtained directly from the authors or through the interlibrary loan service.

All 152 papers were read in detail to determine whether the studies were relevant to enter into the database. Criteria for relevancy included whether a method or tool was discussed in detail, created, and/or studied in relation to measuring and/or valuing a firm's environmental/ ecological impacts. Studies that did not fit these characteristics were removed from the database. In total, 59 studies were deemed relevant (Table A1).

Table A1

Academic Literature Review Search 1 Details

ACADEMIC JOURNAL DATABASES	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
Database			
ProQuest – All of ProQuest including, but not limited to: • ABI/Inform Trade & Industry • CBCA Business • ERIC • ProQuest Asian Business and Reference • ProQuest European Business • ProQuest Science Journals • ProQuest Social Science Journals	72	9	12.50%
Wiley Interscience	91	56	61.54%
JSTOR	367	27	7.36%
EconLit	14	10	71.43%
ISI Web of Knowledge – All of ISI Web of Knowledge including, but not limited to: • Science Citation Index Expanded • Social Sciences Citation Index • Arts & Humanities Citation Index • Conference Proceedings Citation Index – Science • Conference Proceedings Citation Index – Social Science and Humanities	8	8	100.00%
EBSCOhost: Business Source Premier	17	13	76.47%
Totals	569	123	21.62%

Table A1

Academic Literature Review Search 1 Details (Continued)

WEB-BASED SEARCH	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
Website			
GLOBE-Net	0	0	0.00%
Greenbiz.com	0	0	0.00%
Socialfunds.com	0	0	0.00%
CSRwire	0	0	0.00%
United Nations Environment Programme Finance Initiative (UNEPFI)	0	0	0.00%
World Business Council for Sustainable Development	0	0	0.00%
Network for Business Sustainability website	0	0	0.00%
RePEc – Research Papers in Economics	0	0	0.00%
Global Reporting Initiative	18	1	5.56%
Google Scholar Advanced	100	18	18.00%
• No filter: 17300 results; Partially filtered: 15300 results; Significantly filtered: 100 results			
SSRN – Social Science Research Network	184	5	2.72%
Totals	302	24	7.95%
LISTSERVS	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
ResEcon	32	5	15.63%
ONE	1	0	0.00%
Totals	33	5	15.15%
OVERALL TOTALS	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
Overall Totals	904	152	16.81%
ACADEMIC PEER-REVIEWED LITERATURE SEARCH 1 RESULTS	FIRST SCREENING N	SECOND SCREENING N	% USEFUL
Academic Peer-Reviewed Literature Search 1 Results	152	59	38.82%

Search Terms: (measuring OR valuation) AND (firm OR business) AND ("environmental impact" OR "ecological impact")
Search Dates: January 1, 2000 to the Present (January/February 2010)

A more detailed description of the search process is as follows:

ACADEMIC LITERATURE - SEARCH ONE (JANUARY AND FEBRUARY 2010)

Listserv

- ResEcon (56 responses, 32 articles/ reports received, five deemed as potentially relevant).
- ONE (five responses, one article/report received, zero deemed as potentially relevant).

DATABASES

ProQuest

- Relevant search criteria produced 72 results (nine were deemed as potentially relevant).
- Original search criteria resulted in many one-page summaries that were related to the project, but did not provide any significant detail. Many of these were newspaper articles or short summaries of future projects. For example, a one-page summary may have discussed XXX company teaming up with YYY organization to conduct a life cycle analysis, but no detail was provided. Therefore, the original search criteria were filtered further.
- Search criteria were filtered by the following:
  - Excluding book reviews
  - Excluding newspapers
  - Including only scholarly journals, including peer-reviewed journals
- New results revealed 10 results (nine were deemed as potentially relevant).

Wiley Interscience

- Relevant search criteria produced 91 results (56 were deemed as potentially relevant).

JSTOR

- Relevant search criteria produced 367 results (27 were deemed as potentially relevant).

EconLit

- Relevant search criteria produced 14 results (10 were deemed as potentially relevant).

ISI Web of Knowledge

- Relevant search criteria produced eight results (eight were deemed as potentially relevant).

EBSCOhost: Business Source Premier

- Relevant search criteria produced 17 results (13 were deemed as potentially

SPECIALIZED ONLINE SOURCES

GLOBE-Net
- Using the search criteria set forth in this document, no results were returned.

Greenbiz.com
- The search criteria resulted in a one-page article discussing the importance of measuring a firm's environmental/ ecological impacts.

Socialfunds.com
- Approximately 285 company sustainability reports were linked to the website's annual sustainability reports; however, not all links worked. Companies included ranged from 3Com Corporation to General Mills to Yum! Brands, Inc. Information obtained may be able to be used in a case study.

CSRwire
- Offered many links to company sustainability reports. Difficult to count the number of company sustainability reports available, as the report list was vague. Information obtained may be able to be used in a case study.

United Nations Environment Programme Finance Initiative (UNEPFI)
- Many reports existed on this website, although most related to financing and not how to measure and/or value.

World Business Council for Sustainable Development
- Many case studies available.

Network for Business Sustainability website
- Using the search criteria set forth in this document, no results were returned. The search engine restricts the number of characters entered in a search term.

RePEc
- Using the search criteria set forth in this document, no results were returned.

Global Reporting Initiative
- Using the search criteria set forth in this document, 18 results were returned (one study was deemed potentially relevant). Several of the other studies were company sustainability reports, whose information could be used in a case study.

Google Scholar Advanced

- Using the search criteria set forth in this document, 17,300 results were returned.

To limit the search results:

- Did not include patents
- Did not include court information
- Limited to three categories:
  - Business, Administration, Finance and Economics
  - Social Sciences, Arts and Humanities
  - Biology, Life Sciences and Environmental Science

These limitations resulted in 15,300 studies.

To limit the search results further:

- Did not include patents
- Did not include court information
- Limited to one category
  - Business, Administration, Finance and Economics

These limitations resulted in 7,900 studies.

Reviewed the first 100 documents (18 were deemed as potentially relevant); the potentially relevant documents were all found in the first 40 hits. Therefore, going deeper into the list resulted in non-relevant documents.

SSRN – Social Science Research Network

- Using the search criteria set forth in this document, 184 results were returned (five were deemed as potentially relevant).

OVERALL RESULTS

Overall, the search criteria resulted in 904 studies, of which 152 (16.81 percent) were deemed as potentially relevant.

Academic Peer-Reviewed Literature Search 2

Because the first search was not believed to have been sufficiently comprehensive, a second Academic Peer-Reviewed Literature Search was conducted. On the recommendation of the project's Oversight Committee, this search was to include studies obtained by committee members, in addition to studies from one database, the EBSCOhost database. In the first Academic Peer-Reviewed Literature Search, only the EBSCOhost Business Source Premier was searched. This second Academic Peer-Reviewed Literature Search was to include the entire EBSCOhost offering, which includes 17 databases: Academic Search Premier; Australia/New Zealand Reference Centre; Business Source Premier; Communication & Mass Media Complete; Computers & Applied Sciences Complete; EconLit; Education Research Complete; Health Business Fulltext Elite; Health Source – Consumer Edition; Health Source – Nursing/Academic Edition; Hospitality & Tourism Index; Humanities International Complete; Library, Information Science & Technology Abstracts; MAS Ultra – School Edition; MasterFILE Premier; Newspaper Source; and PsycEXTRA.

The new search was to include more keywords than the first search with the aim of capturing more studies. These keywords included the following:

(environmental OR ecological OR sustainab*) AND ("environmental accounting" OR "social performance" OR "environmental impact" OR "ecological impact" or "social responsibility" or "environmental indicator" or "ecological indicator" OR "environmental reporting" or "ecological reporting") AND (firm* OR business* OR organization* OR corporation*) AND (measur* or valu* or methodol* or metric*)

Inventory existing documents focused on measuring and/or valuing a firm's environmental/ecological impacts. Download document citations, including abstracts, into an Endnote file.

The second academic literature search process was conducted in June 2010.

For the first part of the search, members of the project's Oversight Committee sent a list of studies they suggested should be included in the database. This list was obtained in the form of emails sent directly from the committee members and from emails forwarded by the committee members.

The next step in the systematic review process was to search the entire EBSCOhost database. The Ebsco Host database includes the following databases:

- Academic Search Premier
- Australia/ New Zealand Reference Center
- Business Source Premier
- Communication & Mass Media Complete
- Computers & Applied Sciences Complete
- EconLit
- Education Research Complete
- Health Business Fulltext Elite
- Health Source – Consumer Edition
- Health Source – Nursing/ Academic Edition
- Hospitality & Tourism Index
- Humanities International Complete
- Library, Information Science & Technology Abstracts
- MAS Ultra – School Edition
- MasterFILE Premier
- Newspaper Source
- PsycEXTRA
- Psychology and Behavioral Sciences Collection
- Regional Business News
- Religion and Philosophy Collection
- SPORTDiscus
- The Serials Directory

As stated previously, the search string used for this search was as follows:

(environmental OR ecological OR sustainab*) AND ("environmental accounting" OR "social performance" OR "environmental impact" OR "ecological impact" or "social responsibility" or "environmental indicator" or "ecological indicator" OR "environmental reporting" or "ecological reporting") AND (firm* OR business* OR organization* OR corporation*) AND (measur* or valu* or methodol* or metric*)

In addition to using the keywords, the search was truncated by the following details:

- Studies were to be more than two pages because studies of fewer than two pages were typically newspaper reports or summaries.
- To reduce the time necessary to collect the documents, only full-text studies were considered. In the first search, many of the studies not available online were solicited directly from the authors; however, these studies often took several months to be received, a time lag that was no longer an option for this second search.
- Only peer-reviewed studies were considered, to be consistent with the first academic literature search process.
- Only studies published between January 2000 and the present (June 2010) were considered, again to be consistent with the first academic literature search process.

In total, 650 potential papers were identified. The citations, including the abstracts, of these papers were downloaded into an Endnote file.
Initial screening of retrieved documents:

- Delete duplicate references.
- Screen title and abstract of retrieved documents for relevancy to measuring and/or valuing a firm's environmental/ ecological impacts. Delete irrelevant documents from Endnote file.

During the initial screening, duplicate references were removed. For a few of the studies, the same reference appeared from two to five times in the Endnote file. These results were then compared with the results from the Academic Peer-Reviewed Literature Search 1, as several of these studies were the same. Duplicates between Search 1 and Search 2 were then deleted from the Endnote file.

After duplicate references were removed, search results were scrutinized individually for relevance, as determined by the titles and abstracts.

From the original 650 studies identified, 96 were deemed as potentially relevant studies; however, only 91 were relevant in relation to academic studies, the other five were more relevant for practitioner studies and were then transferred to the practitioner list. The result was 645 original academic studies, of which 91 were deemed as potentially relevant.
Secondary screening of retrieved documents:

- Download full copies of all potentially relevant documents.
- Review all potentially relevant documents in detail. Delete irrelevant documents from the Endnote file.

During the first part of the secondary screening process, full-text copies were obtained of all 96 potentially relevant studies (91 academic studies and five practitioner studies). Studies were obtained either directly from the Oversight Committee or downloaded from the Internet.

All 91 academic papers were read in detail to determine whether the studies were relevant to enter into the database. Criteria for relevancy included whether a method or tool was discussed in detail, created and/or studied in relation to measuring and/or valuing a firm's environmental/ ecological impacts. Studies that did not fit these characteristics were removed from the database. In total, 74 academic studies were deemed relevant (Table A2).

Table A2

ACADEMIC LITERATURE REVIEW SEARCH 2 DETAILS

ACADEMIC JOURNAL DATABASES	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
Database			
EBSCOhost	629	82	13.04%
• Academic Search Premier			
• Australia/New Zealand Reference Centre			
• Business Source Premier			
• Communication & Mass Media Complete			
• Computers & Applied Sciences Complete			
• EconLit			
• Education Research Complete			
• Health Business Fulltext Elite			
• Health Source – Consumer Edition			
• Health Source – Nursing/Academic Edition			
• Hospitality & Tourism Index			
• Humanities International Complete			
• Library, Information Science & Technology Abstracts			
• MAS Ultra – School Edition			
• MasterFILE Premier			
• Newspaper Source			
• PsycEXTRA			
• Psychology and Behavioral Sciences Collection			
• Regional Business News			
• Religion and Philosophy Collection			
• SPORTDiscus			
• The Serials Directory			
Totals	629	82	13.04%

Table A2

ACADEMIC LITERATURE REVIEW SEARCH 2 DETAILS (Continued)

SUSTAINABILITY COMMITTEE SUGGESTIONS	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
Original Messages	15	11	73.33%
Forwarded Messages	6	3	50.00%
Totals	21	14	66.67%
TRANSFER TO PRACTITIONER STUDY SECTION	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
Transfer to Practitioner Study Section	-5	-5	0.00%
Totals	-5	-5	0.00%
OVERALL TOTALS	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
Overall Totals	645	91	14.11%
ACADEMIC PEER-REVIEWED LITERATURE SEARCH 2 RESULTS	FIRST SCREENING N	SECOND SCREENING N	% USEFUL
Academic Peer-Reviewed Literature Search 2 Results	91	74	81.32%

Search Terms: (environmental OR ecological OR sustainab*) AND (“environmental accounting” OR “social performance” OR “environmental impact” OR “ecological impact” or “social responsibility” or “environmental indicator” or “ecological indicator” OR “environmental reporting” or “ecological reporting”) AND (firm* OR business* OR organization* OR corporation*) AND (measur* or valu* or methodol* or metric*)
Search Dates: January 1, 2000 to (June 2010)

A more detailed description of the search process is as follows:

ACADEMIC LITERATURE - SEARCH TWO (JUNE 2010)

OVERSIGHT COMMITTEE RECOMMENDATIONS

- Direct emails (four responses, 15 articles/reports received, 11 deemed as potentially relevant).
- Note that all articles received were relevant in terms of the project; however, several were not in the 2000–2010 date range and were therefore not included.
- Forwarded emails (three responses, six articles/reports received, three deemed as potentially relevant).

DATABASES

EBSCOhost

- Original keyword search produced 3861 results
- New results revealed 629 results (82 were deemed as potentially relevant).
- Search criteria were filtered by the following:
  - Studies more than two pages in length
  - Full-text studies
  - Peer-reviewed studies
  - Studies published between January 2000 and June 2010
  - New results revealed 650 results (96 were deemed as potentially relevant).

OVERALL RESULTS

Overall the search criteria resulted in 650 studies, of which 96 (14.77 percent) were deemed as potentially relevant. However, of the 96 studies, five were found to be relevant for the practitioner study and not the academic study and were transferred into the practitioner database. This move resulted in 645 relevant studies, of which 91 (or 14.11 percent) were deemed as potentially relevant.

Practitioner Literature Search

The next step was to search the Practitioner Literature. This search was to include studies obtained by members of the Oversight Committee in addition to studies resulting from a Google search.

To be consistent with Academic Peer-Reviewed Literature Search 2, the same keywords would be used:

(environmental OR ecological OR sustainab*) AND ("environmental accounting" OR "social performance" OR "environmental impact" OR "ecological impact" or "social responsibility" or "environmental indicator" or "ecological indicator" OR "environmental reporting" or "ecological reporting") AND (firm* OR business* OR organization* OR corporation*) AND (measur* or valu* or methodol* or metric*)

Inventory existing documents focused on measuring and/or valuing a firm's environmental/ecological impacts. Download document citations, including abstracts, into an Endnote file.

The practitioner literature search process was conducted in July 2010. For the first part of the search, members of the project's Oversight Committee sent a list of studies they suggested should be included in the database. This list was obtained in the form of emails sent directly from the committee members and from emails forwarded by the committee members.

The next step in the systematic review process was to conduct a Google search. It was determined that only the first 100 results in the search would be considered. Of those results, only those with PDF files would be considered.

When the initial search string was entered, it obtained no results. After some experimentation, the quotation marks were removed from the search terms. The removal of the quotation marks resulted in a successful search. As such, the search string was:

(environmental OR ecological OR sustainab*) AND (environmental accounting OR social performance OR environmental impact OR ecological impact or social responsibility or environmental indicator or ecological indicator OR environmental reporting or ecological reporting) AND (firm* OR business* OR organization* OR corporation*) AND (measur* or valu* or methodol* or metric*)

From the first 100 results, 85 were PDF files and deemed as potentially relevant to the study.
Initial screening of retrieved documents:

- Delete duplicate references.
- Screen title and abstract of retrieved documents for relevancy to measuring and/or valuing a firm's environmental/ ecological impacts. Delete irrelevant documents from Endnote file.

During the initial screening, duplicate references were to be removed; however, no duplicate references were located.

Search results were then scrutinized individually for relevance as determined by the titles and abstracts.

From the original 85 studies identified, 56 were deemed as potentially relevant studies.

Secondary screening of retrieved documents:

- Download full copies of all potentially relevant documents.
- Review all potentially relevant documents in detail. Delete irrelevant documents from the Endnote file.

During the first part of the secondary screening process, full-text copies were obtained of all 60 potentially relevant studies. Studies were obtained either directly from the Oversight Committee or downloaded from the Internet.

All 56 papers were read in detail to determine whether the studies were relevant to enter into the database. Criteria for relevancy included whether a method or tool was discussed in detail, created, and/or studied in relation to measuring and valuing a firm's environmental/ecological impacts. Studies that did not fit these characteristics were removed from the database. In total, 47 studies were deemed relevant (Table A3).

A more detailed description of the search process is as follows:

PRACTITIONER LITERATURE SEARCH (JULY 2010)

OVERSIGHT COMMITTEE RECOMMENDATIONS

- Direct Requests (eight responses, 18 articles/reports received, 14 deemed as potentially relevant).
- Note that all articles received were relevant in terms of the project; however, several were not in the 2000–2010 date range and were therefore not included.
- Forwarded emails (three responses, 21 articles/reports received, nine deemed as potentially relevant).

DATABASES

Google

- Relevant search criteria produced 462,000 results.
- The first 100 results were to be considered.
- Only PDF files were considered.
- Upon further investigation of the 462,000 results, only 50 actual results were visible. Perhaps the 462,000 results represented the 50 studies, and when the studies were looked at in detail, all duplicate results were deleted.
- Of the 50 studies, 37 were PDF files, all of which were deemed to be relevant to the study.

TRANSFERRED

- Five studies found in the academic search were transferred to the practitioner search.

REMOVAL OF DUPLICATES

- Because files on the Internet have many different names, nine sets of duplicates were found in the practitioner literature. Therefore, those nine duplicate studies were removed.

OVERALL RESULTS

Overall, the search criteria resulted in 85 studies, of which 56 (65.88 percent) were deemed as potentially relevant.

Table A3

PRACTITIONER LITERATURE REVIEW SEARCH DETAILS

WEB-BASED SEARCH	ORIGINAL N	FILTERED N	% POTENTIALLY USEFUL
Website			
Google	50	37	74.00%
Original Results: 463000 results; Partially filtered: 100 results; Significantly filtered: 50 results			
Totals	50	37	74.00%
SUSTAINABILITY COMMITTEE SUGGESTIONS	**ORIGINAL N**	**FILTERED N**	**% POTENTIALLY USEFUL**
Original Messages	18	14	77.78%
Forwarded Messages	21	9	42.86%
Totals	39	23	58.97%
LITERATURE FROM ACADEMIC SEARCH	**ORIGINAL N**	**FILTERED N**	**% POTENTIALLY USEFUL**
Transferred from Academic Search	5	5	100.00%
Totals	5	5	100.00%
REMOVAL OF DUPLICATES	**ORIGINAL N**	**FILTERED N**	**% POTENTIALLY USEFUL**
Removal of duplicates from studies having different saved names	-9	-9	100.00%
Totals	-9	-9	100.00%
OVERALL TOTALS	**ORIGINAL N**	**FILTERED N**	**% POTENTIALLY USEFUL**
Overall Totals	85	56	65.88%
PRACTITIONER LITERATURE SEARCH 3 RESULTS	**FIRST SCREENING N**	**SECOND SCREENING N**	**% USEFUL**
Practitioner Literature Search 3 Results	56	47	83.93%

Search Terms: (environmental OR ecological OR sustainab*) AND (environmental accounting OR social performance OR environmental impact OR ecological impact or social responsibility or environmental indicator or ecological indicator OR environmental reporting or ecological reporting) AND (firm* OR business* OR organization* OR corporation*) AND (measur* or valu* or methodol* or metric*)
Search Dates: January 1, 2000 to the Present (July 2010)

SUMMARY OF THE LITERATURE REVIEW PROCESS

The literature search originally resulted in 1634 potential studies: 904 from the first academic literature search, 645 from the second and 85 from the practitioner search. After the first screening, 299 studies remained: 152 from the first academic literature search, 91 from the second academic literature search and 56 from the practitioner search. After the second screening, 180 studies were entered into the database: 59 from the first academic literature search, 74 from the second and 47 from the practitioner literature search (Table A4).

Table A4

OVERALL LITERATURE REVIEW RESULTS

RESULTS	ORIGINAL N	FIRST SCREENING N	% POTENTIALLY USEFUL (FIRST SCREENING/ ORIGINAL N)	SECOND SCREENING N	% USEFUL (SECOND SCREENING/ ORIGINAL N)	% USEFUL (SECOND SCREENING/ FIRST SCREENING)
Academic Peer-Reviewed Literature Search 1	904	152	16.81%	59	6.53%	38.82%
Academic Peer-Reviewed Literature Search 2	645	91	14.11%	74	11.47%	81.32%
Practitioner Literature Search 3	85	56	65.88%	47	55.29%	83.93%
Totals	1634	299	18.30%	180	11.02%	60.20%

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Appendix C. Tool Definitions

Balanced Scorecard Approach

The Balanced Scorecard Approach is a strategic planning and management tool used by organizations to record and evaluate financial and non-financial measures. Several researchers have modified the original Balanced Scorecard proposed by Kaplan and Norton (1992) to be more balanced, by including social, environmental and financial aspects; others, however, believe the original Balanced Scorecard considered all of these aspects. One way to build on the original model is to include the triple bottom line into a balanced scorecard. Another way is to include the principle environmental impacts.

Carbon Footprint/Carbon Performance Indicators

A carbon footprint is a calculation of the total amount of greenhouse gas emissions linked to an organization, firm, product or person. It is commonly expressed in amounts of carbon dioxide. This tool is a subset of the ecological, or environmental, footprint and the life cycle analysis method. Some organizations attempt to offset, or mitigate, their carbon footprint by investing in alternatives such as solar energy, wind energy and reforestation projects (Chambers et al., 2007; Wiedmann and Minx, 2008).

Cost-Benefit Analysis

Cost-benefit analysis, also known as benefit-cost analysis, is an economic tool used to weigh the total expected benefits against the total expected costs for a variety of scenarios (including status quo) when assessing the case for a new policy proposal, project, product or program. In a complete cost-benefit analysis, all environmental and social costs are considered, thus identifying the trade-off between environmental and social quality and economic goods (Hussen, 2000).

Destination Environmental Scorecard

A destination environmental scorecard, also called a local environmental activity scorecard, is a measurement tool used by small- and medium-sized hotels to measure and compare their performance such that they can conduct their operations to be responsible and to benefit both their financial performance and the region's sustainability (Karatzoglou and Spilanis, 2010).

Ecological Footprint

The ecological footprint, also called the environmental footprint, measures human demand on the ability of affected ecosystems to regenerate, including resources consumed and wastes generated. The ecological footprint is typically measured by the amount of biologically productive land and water area required (Dietz et al., 2007; York et al., 2003).

Ecosystem Service Valuation

Ecosystem services are those services that contribute directly to life and include genetic and medicinal resources, plant and animal refugia, purification and regulation of air and water, soil formation, detoxification and decomposition of wastes, plant pollination, natural pest and biological control, nursery function, seed dispersal, nutrient cycling, biodiversity maintenance, protection from the sun's ultraviolet rays, partial climate stabilization, natural disturbance regulation, raw materials, food production, erosion control, aesthetic beauty, human culture, recreation, preservation (including existence, bequest and option values) and science and education.

Ecosystem service valuation is the process of placing values on the ecosystem services in an area of concern and determining how the values and ecosystem services will change as a consequence of the implementation of a project or the enforcement of a land management policy. In this way, ecosystem service valuation calculates the total economic value of the ecosystem goods and services in terms of the flows of benefits and costs provided by the stock of natural capital (Costanza et al., 1997; Daily, 1997; Daily et al., 1997; De Groot et al., 2002; Eftec, 2006; Kaval, 2010).

Environmental Evaluation Matrix

An environmental evaluation matrix is a tool used to assimilate environmental information to appraise projects, essentially by using the adapted project life cycle framework. The matrix considers the "Design for Environment" principles (Graedel and Allenby, 1995; Labuschagne et al., 2005).

Environmental Footprint

See Ecological Footprint.

Environmental Input-Output Model

An environmental input-output model is an economic tool that can be used to describe an organization's flow of goods and services, including environmental effects. This tool also demonstrates how organizations are linked together because organizations use the products and/or services from other organizations to produce their own goods and/or services. The input-output model was introduced by Wassily Leontief in 1951 (Collins et al., 2007; Gay et al., 2005; Leontief, 1951; Wiedmann et al., 2007).

Environmental Management System Modelling

Environmental management System (EMS) modelling is a tool that can be used to improve the environmental performance of an organization. The tool focuses on providing a systematic methodology of managing an organization's environmental programs by considering both the short- and long-term environmental impacts of its goods and/or services. This process typically involves creating an environmental policy statement; identifying significant environmental impacts; developing targets and objectives; implementing plans to meet those targets and objectives, including training employees to assist in fulfilling the environmental obligations; and reviewing and updating the process as necessary. The entire EMS can include policies, task lists, data organization, audits and environmental reports (Christini et al., 2004; Rao et al., 2006; Tam et al., 2006).

Epstein Roy Framework

The Epstein Roy Framework is a comprehensive approach used to examine corporate sustainability drivers, the ways in which managers can affect sustainability performance and the corporate social and financial performance consequences. It can also assist an organization's managers and researchers in creating, applying and analyzing their sustainability strategy (Epstein and Roy, 2001).

Genuine Wealth Accounting Model and Genuine Wealth Balance Sheet

The Genuine Wealth Accounting Model is grounded in traditional double-entry accounting conventions and encompasses five core capital assets. These assets include social, manufactured, human, financial and natural capital. In this way, genuine wealth includes all things that make life worthwhile. As such, intangible and tangible assets are included, such as the strength of relationships with our friends and family, in addition to the ecosystem services that nature provides. It can also be termed economic well-being. The Genuine Wealth Balance Sheet is a tool for entering and evaluating Genuine Wealth (Daly et al., 2005).

Green Globes Design

Green Globes focuses on improving the sustainability and environmental performance of commercial buildings and includes the following elements: an extensively detailed environmental assessment protocol, best practice guidance for green construction, software tools, qualified assessors that are experts in green construction, and a rating and certification system. Green Globes Design can be applied to new buildings, significant renovations, and the management and operation of existing buildings (Cole, 2006).

Green Productivity Index

The Green Productivity Index focuses on the integration of environmental protection into corporate performance and is calculated as the ratio of selling price to production cost (i.e. productivity) of a system as compared with its environmental impact, which includes solid waste generation, gaseous waste generation and water consumption. The purpose of the Green Productivity Index is to improve environmental decision-making and to promote environmental reporting and planning (Gandhi et al., 2006; Hur et al., 2004; Saxena et al., 2003).

Life Cycle Analysis

A life cycle analysis, also called a life cycle assessment, simplified life cycle analysis, cradle-to-grave analysis or eco-balance, is a methodological tool focused on quantitatively evaluating the environmental and social damages related to a specific service or product. The entire life cycle of the service or product is considered, including from product or service design to manufacturing, disposal and all steps in between. The International Organization for Standardization 14000 promotes and recommends using life cycle analysis procedures in corporate sustainability reporting (Hunter and Bansal, 2007; Karapetrovic and Jonker, 2003; Lopez et al., 2007b; Tam et al., 2006).

Lowell Center Hierarchy

The Lowell Center Hierarchy is a tool used to assist companies and communities in evaluating the effectiveness of their sustainability principles by measuring progress. The hierarchy was developed at the Lowell Center for Sustainable Production, University of Massachusetts Lowell (United States). The tool's assumptions are based on a five-level hierarchy that includes compliance/conformance, resource use and performance, local effect indicators, upstream and downstream/supply-chain, and life cycle indicators and sustainable systems indicators (Gerbens-Leenes et al., 2003; Veleva et al., 2003).

Materials Flow Analysis

Materials flow analysis, also called substance flow analysis, is similar to a life cycle analysis and is used in the area of industrial ecology to study the linkages between society and the environment. This tool analyzes both the flow of a material through an industry or firm and the affected ecosystems. Material flow analysis can analyze the effects on a national scale, a regional scale, a corporate or industrial scale or during the life cycle of a product (Hobbes et al., 2007).

Responsive Business Scorecard

The Responsive Business Scorecard is a tool that can be used by companies to integrate stakeholder demands and the company's environmental, social and financial goals to improve performance. This tool considers five perspectives: suppliers and customers, the plant and society, internal processes, owners and financiers, and learning and employees (Caldelli and Parmigiani, 2004; van der Woerd and van den Brink, 2004).

Sustainable Value Added

Sustainable Value Added considers economic, environmental and social aspects simultaneously and is inspired by the concept of strong sustainability, when all forms of capital are kept constant. This tool illustrates the value created when a company becomes more efficient, by measuring extra value, while at the same time making sure all environmental and social impacts remain at a constant level. In this way, eco-efficiency and social efficiency are considered (Figge and Hahn, 2004).

Triple Bottom Line Reporting

Triple bottom line reporting expands on a typical economic accounting method to include ecological and social aspects. This tool is the dominant approach recommended by the United Nations standard for urban and community accounting created in early 2007 because it considers public sector full-cost accounting. According to the concept of triple bottom line reporting, a company's responsibility falls to the stakeholders, not the shareholders; therefore, stakeholder interests are more important than maximizing the profits of shareholders (Ballou et al., 2006; Elkington et al., 2006; New Belgium Brewing Company, 2009; Schafer, 2005).

Whole Life Value

Whole life value is a tool that considers a life cycle analysis in addition to the values of clients or other stakeholders. These client values include a definition of the sustained use aspects of the values a project delivers, a determination in how to identify stakeholders and a determination of how stakeholders can be considered in the evaluation of a facility process (Holt, 2001).

Appendix D. Guidelines and Standards

In addition to these measurement and valuation tools, the review identified many guidelines that individuals, firms and organizations follow when considering sustainability reporting. The following list of guidelines is a good starting point, with each recommending specific methodologies; for example, the Global Reporting Initiative Reporting Framework recommends conducting a life cycle analysis of products. The following is a list of the guidelines discussed in the studies in the database, as well as corresponding links to learn more about them.

Association of Chartered Certified Accountants (ACCA) Sustainability Reporting Guidelines
http://www.accaglobal.com/general/activities/sustainability/reporting

European Foundation for Quality Management Business Excellence Model
http://www.efqm.org/en/

European Sustainability Reporting Organization
http://www.sustainabilityreporting.eu/

Global Reporting Initiative Reporting Framework
http://www.globalreporting.org/ReportingFramework/

International Federation of Accountants Sustainability Reporting Framework
http://web.ifac.org/sustainability-framework/ohp-format-and-content

International Organization for Standardization: International Standards for Business, Government and Society
http://www.iso.org/iso/iso_14000_essentials

The Natural Step's Four System Conditions
http://www.naturalstep.org/the-system-conditions

Organisation for Economic Co-operation and Development: OECD Guidelines for Multinational Enterprises
http://www.oecd.org/department/0,3355,en_2649_34889_1_1_1_1_1,00.html

System of Environmental and Economic Accounting for Water
http://unstats.un.org/unsd/envaccounting/seeaw.asp

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about NBS

A Canadian non-profit established in 2005, the Network for Business Sustainability produces authoritative resources on important sustainability issues – with the goal of changing management practice. We unite thousands of researchers and professionals worldwide who believe passionately in research-based practice and practice-based research.

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NBS Knowledge Centre

For additional resources visit NBS' Knowledge Centre at nbs.net/knowledge/impacts.

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NBS' Leadership Council is a group of Canadian sustainability leaders from diverse sectors. At an annual meeting, these leaders identify their top priorities in business sustainability – the issues on which their organizations need authoritative answers and reliable insights. Our 2009 Leadership Council inspired and funded this research project.

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