UNIVERSITY OF CALIFORNIA
Santa Barbara

SUSTAINABLE SUPPLY CHAIN MANAGEMENT: A FRAMEWORK TO ASSESS AND REDUCE ENVIRONMENTAL IMPACTS FROM UCSB PROCUREMENT

A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management for the Bren School of Environmental Science & Management

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Sustainable Supply Chain Management:
A Framework to Assess and Reduce Environmental Impacts from UCSB Procurement

As authors of this Group Project report, we are proud to archive this report on the Bren School's website such that the results of our research are available for all to read. Our signatures on the document signify our joint responsibility to fulfill the archiving standards set by the Bren School of Environmental Science & Management.

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The mission of the Bren School of Environmental Science & Management is to produce professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principal of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

John Melack

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LIST OF ACRONYMS

BEA - Bureau of Economic Analysis

Bren School – Bren School of Environmental Science & Management at UCSB

CEDA - The Comprehensive Environmental Data Archive (CEDA) is a suite of environmentally extended input-output databases that are designed to assist various environmental systems analyses and life cycle assessments, including carbon footprinting, water footprinting and embodied energy analysis.

CMU - Economic Input Output on-line tool developed by the Green Design Institute for Carnegie Melon University to quickly and easily evaluate the environmental impacts of a commodity or service, as well as its supply chain.

CSP - Campus Sustainability Plan

EDF - Environmental Defense Fund

EIO-LCA - Economic Input Output Life Cycle Assessment

EPA - (Federal) Environmental Protection Agency

EPEAT - EPEAT® is a global certification for environmentally preferable electronics

EPP - Environmentally Preferable Purchasing

ERI - Earth Research Institute

GHG - Greenhouse Gases

GWP - Global Warming Potential

IO - Input Output

ISO - International Organization for Standardization

LCA - Life Cycle Assessment

LCI - Life Cycle Inventory

LCIA - Life Cycle Impact Assessment

NAICS - The North American Industry Classification System (NAICS) is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy.

SSCM - Sustainable Supply Chain Management

TGIF - The Green Initiative Fund

TRACI – Tool for the Reduction and Assessment of Chemical and other Environmental Impacts

UCOP - University of California, Office of the President

UCSB – University of California, Santa Barbara

ABSTRACT

This project provides the University of California, Santa Barbara (UCSB) with a framework to efficiently assess and improve sustainable purchasing that incorporates its new centralized online campus procurement system. To accomplish this, economic input-output life cycle assessment (EIO-LCA) was used to identify purchases with the greatest environmental impacts from the Bren School of Environmental Science & Management, Earth Research Institute, Department of Geography, Department of Psychology and Brain Science, and Central Stores, a campus wholesaler that provided office and cleaning supplies in 2011-12. A literature-based process LCA was conducted on one of the highest impact products, copy paper, to compare the impacts of reducing paper consumption against those of using paper with higher recycled content. A survey was conducted among campus purchasers to examine purchasing behavior. Results of the EIO-LCA showed that, of campus-wide purchases, sanitary paper, paper, and cleaning products had the highest contributions to global warming. Results among departments varied, in accordance with different purchasing patterns. The process LCA for copy paper showed that 50% recycled content would be needed to equal the same reduction in impact as an 8% decrease in overall paper consumption. Results from the survey showed that while 81% of respondents said they were likely to buy a sustainable product, less than 50% actually made sustainable purchases. 33% said they did not know where to find a more sustainable option. Recommendations for UCSB include: 1) using the new online purchasing system to track and monitor purchases, 2) leveraging purchasing power with suppliers using the information gained, 3) pairing the tracked purchase information with EIO-LCA to identify high impact products and then 4) eliminating, reducing or substituting high impact products with lower impact products (if possible), 5) and surveying campus purchasers annually or bi-annually to monitor purchasing behavior and identify opportunities for education or improvement within the purchasing system.

EXECUTIVE SUMMARY

A coordinated plan for measuring and reducing environmental impacts along its supply chain allows the University of California, Santa Barbara (UCSB) to become more efficient, while reducing costs and environmental impacts. This will also improve UCSB's ability to attract top faculty and student talent. This project intends to help UCSB reduce its negative environmental impact by creating a framework to identify and target products with high environmental impacts and develop strategies to mitigate these impacts.

Four key objectives to increase sustainability along UCSB's supply chain include:

- Develop a framework for assessing the environmental impacts of UCSB's purchases
- Develop methodology for targeting areas to reduce environmental impacts
- Perform an analysis of UCSB's purchasing behavior
- Prescribe strategies to optimize sustainable purchases within the procurement system

To reduce harmful environmental impacts resulting from purchasing goods and services required for developing human capital and academic innovation, an assessment of products with the highest proportional impacts is necessary. Once this information is obtained, high-impact products can be targeted for reduction through methods of restriction, reduction or substitution along the supply chain. The project's results and recommendations will assist UCSB and the University of California (UC) system in achieving both campus and system-wide sustainability objectives.

Background

The UC System Board of Regents has prescribed sustainability goals in a UC Sustainable Practices Policy. These include a pledge to reduce greenhouse gas emissions (GHG) to 1990 levels, as well as a policy to maximize procurement of environmentally preferable products (EPP) and services. In order to reduce GHGs most effectively through purchasing changes, it is first necessary to understand what the largest contributors are among currently purchased products.

In 2013, UCSB transitioned to a centralized purchasing system after years of operating on several different accounting information systems. This new system, called Gateway, can capture detailed information for all purchasing transactions; data which was not available at the time of this study. Gateway can also be used as a tool to increase the sustainability of purchasing by affecting the types of products purchased, as well as the knowledge and behavior of the purchasers across campus. One of the objectives of this project is therefore to determine how Gateway can be leveraged to help meet the UC sustainability goals.

Methodology

This project employs several life cycle assessment (LCA) tools and methods, following the principles and guidelines of the International Organization for Standardization (ISO), to determine the most effective methods for assessing products with the greatest environmental impacts. Specifically, LCA models were used to establish the products purchased in 2011-2012 with the greatest associated levels of GHGs or global warming potential (GWP) for the Bren School of Environmental Science & Management, Earth Research Institute, Department of Geography, Department of Psychology and Brain Science, and Central Stores, a campus wholesaler that provided office and cleaning supplies in 2011-12. This subset was used as it contained detail on the type and quantity of products purchased over the 2011-12 fiscal year, while the majority of the University did not maintain this information.

The study implemented a 21-question survey, which was completed by 156 campus employees, 100 of whom made purchases on campus. The survey improved the project's ability to understand purchasing behavior, attitudes of purchasers, and the barriers and opportunities that exist within campus purchasing. These results are valuable for optimizing Gateway to improve sustainability along UCSB's supply chain.

Results

Using the $3,765,300 of campus expenditures available and compatible with Economic Input-Output Life Cycle Assessment (EIO-LCA) tools, it was found that the total estimated GWP from the sample study was 1.86 million kg carbon dioxide equivalents (CO_2eq). The greatest contributors to GWP were electronic computers, scientific research and development services, sanitary paper products, and office paper products. These four product categories contributed to 56% of the GWP of the 183 product categories included in the analysis. Central Stores constituted the largest percentage of expenditure on paper products, while Earth Research Institute and the Department of Psychology & Brain Sciences purchases were related to scientific research and laboratory equipment. The Bren School's purchases were mostly computer related and the Geography Department largely included computers and other communication devices. The differences in high impact product categories showed the importance in looking at both the overall campus and the differences in departments to make recommendations for sustainable purchasing.

One product category was analyzed as a case study for the purchasing department. Paper mills was the sector targeted because of its large contribution to GWP, with roughly 225,320 kg CO_2eq and 12% of the sample study's total GWP. Within paper mills, copy paper constituted about 94% of the GWP, and was chosen for further analysis. A more detailed LCA method was used to determine the best way to reduce GWP, including restricting or reducing use, or substituting for a more environmentally friendly alternative. An 8% reduction in copy paper use was equal to an increase from all copy paper at 30% post-consumer recycled content to 50% post-consumer recycled content, in terms of reducing GWP. While it is acknowledged that substituting and reducing products often result in tradeoffs of environmental impacts, an analysis of such environmental tradeoffs was beyond the scope of this study.

Key survey results indicated that while UCSB purchasers frequently consider sustainability, they often do not buy sustainable products. This revealed an information gap between a desire to purchase sustainable products and a lack of doing so. Another key finding showed that purchasers struggle to find sustainable products. Opportunities from these findings include education for department buyers regarding UC sustainability goals, sustainable products, and where to find them in Gateway, and the need to make sustainable products visible on Gateway. The survey confirmed that paper is frequently purchased, and thus an appropriate target category for increased sustainability efforts. These results are valuable for improving sustainability in the procurement process.

Recommendations and Conclusions

This study developed a framework for UCSB to improve its environmental impact. It found that Gateway can be used as a tool to monitor and track campus expenditures, and linked with an EIO-LCA model to pinpoint the products being purchased with large environmental impacts. Once these product categories are identified, further analysis should determine whether purchase restrictions, reduction, or substitution for environmentally friendly alternatives have the greatest environmental benefits, based on a process-based LCA, when possible. This information can be used to develop an Environmentally Preferable Products (EPP) list to be incorporated into Gateway.

Using the purchase data captured by Gateway and the environmental impact data from the EIO-LCA, UCSB can leverage its buying power to renegotiate contracts for sustainable products and pressure its vendors to both increase sustainable product offerings and improve supply chain transparency. This framework can be used as a model for the UC system and other campuses.

PROJECT OBJECTIVES

The goal of this project was to develop a framework for UCSB to assess and reduce the environmental impacts that result from its purchases. This will allow the University to strategically align its purchasing system to meet campus sustainability objectives. In developing a method to capture quantitative information about environmental impacts, UCSB can measure its progress for achieving target reductions. This project serves as a pilot for UCSB and the UC system, to improve the sustainability of its supply chain. The following are specific objectives to achieve the overarching goal to develop a systematic approach for improving the sustainability of UCSB's supply chain.

- Develop a framework for assessing the environmental impacts of UCSB's purchases
- Develop methodology for targeting areas to reduce environmental impacts
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PROJECT SIGNIFICANCE

A coordinated plan for measuring and reducing environmental impacts along its supply chain will provide UCSB with the means to improve operational efficiency and enhance value. Sustainable supply chain management (SSCM) aims to optimize material and information flow along the value chain by increasing ecological and sociological emphasis, in addition to financial considerations, in managerial decisions (Kumar et al., 2012). This triple bottom line approach has gained traction in the private sector and allows public universities to capture similar benefits including improved efficiency, cost savings, and acquisition of top faculty and student talent.

In order to develop a baseline analysis for its environmental impacts, it is important for UCSB to obtain detail of the type, quantity and cost of the products it purchases. Historically, the University has functioned using several accounting information systems, dispersed across different academic departments and administrative divisions. Furthermore, general object coding was often used that did not accurately capture product information necessary to assess environmental impacts. As of 2013, UCSB has transitioned to a centralized e-commerce system called Gateway that can capture detailed information for all transactions. The significance of this project is enhanced due to the timeliness of Gateway's implementation. Developing a framework for environmental impact assessment and reduction from campus purchases can influence the ability of Gateway to serve as an effective tool for continued analysis and reductions of environmental impacts.

By obtaining quantitative information of environmental impacts, UCSB can measure its progress towards achieving campus and UC-wide sustainability goals. In August 2011, the UC Office of the President (UCOP) revised its Sustainable Practices Policy to incorporate environmentally preferable purchasing (EPP). This governing document establishes goals in eight areas of sustainable practices including EPP, green building, clean energy, transportation, climate protection, sustainable operations, waste reduction and recycling, and sustainable foodservice. The development of this project can assist in future performance measurement of the goals outlined in EPP and other areas of sustainable practices. By using product data to assess and reduce its environmental impacts, UCSB can achieve its goals and lead other UC campuses into a new era of sustainable procurement awareness, impacting $2 billion in goods and services procured annually system-wide.

BACKGROUND

UNIVERSITY OF CALIFORNIA

The UC System includes over 220,000 students, 170,000 faculty and staff, and consists of 10 campuses: Berkeley, Davis, Irvine, Los Angeles, Merced, Riverside, San Diego, San Francisco, Santa Barbara, and Santa Cruz, numerous laboratories, medical centers, museums, concert halls, art galleries, observatories and marine centers.

In 2004, the UC System started to focus officially on sustainability. The UC System's Board of Regents implemented sustainability goals including green building and clean energy policies. The Senior Vice President of Business and Finance commenced the Sustainability Steering Committee, involving people from the Vice Chancellor level to undergraduate student representatives. In August 2011, the UC's sustainability goals within the Sustainable Practices Policy were updated and expanded the original goals to include sustainable transportation, climate protection practices, building renovations, sustainable operations and maintenance, water reduction, environmentally preferable purchasing, and sustainable food service. The Sustainable Steering Committee now includes seven Policy Working Groups with representatives from each UC campus that collaborate and recommend policy amendments to the Committee.

The updated version of the UC Sustainable Practices Policy (UC Policy) includes a UC System pledge to:

1. Reduce greenhouse gas emissions to 1990 levels
2. Purchase 20% sustainable food
3. Achieve zero waste

To achieve zero waste, sustainable purchasing at all levels of the UC System needed to be addressed. To fulfill this, requirements in the UC System's purchasing contracts include ENERGY STAR designation, bronze rating EPEAT certification and an equivalent cost for virgin paper and paper of 30% post-consumer recycled content. While the UC System commits to environmentally responsible purchasing, gaps in knowledge hinder significant increases in sustainable purchasing.

Seven Environmentally Preferable Purchasing Practices listed in the UC Policy include:

1. Environmentally preferable purchasing underlies and enables all other areas of sustainable practice in this Policy. Therefore, the University will maximize its procurement of environmentally preferable products and services.
2. The University will use its purchasing power to target environmentally preferable products and services for volume-discounted pricing to make them cost-competitive with conventional products and services.

3. For products and services without available environmentally preferable alternatives, the University will work with its existing and potential supplies and leverage the University's purchasing power and market presence to develop sustainable choices.
4. The University will integrate sustainability requirements into its practices for competitive bidding in material and services procurement, allowing for supplies that meet these requirements to earn additional evaluation points.
5. Packing for all products procured by the University should be designed, produced, and managed in an environmentally sustainable manner. The University shall seek products that have take-back programs, as appropriate.
6. When requested, suppliers citing environmentally preferable purchasing claims shall provide proper certification or detailed information on environmental claims, including benefits, durability, take-back, reuse, and recyclable properties. Additionally, suppliers are responsible for providing proof of University of California-accepted third-party certification based upon the requirements of the University's Procurement Services Department located in the Office of the President.
7. All policy and procedures for environmentally preferable purchasing are to be applied by the University within the constraints of research needs and budgetary requirements and in compliance with applicable rules, regulations and laws.

UNIVERSITY OF CALIFORNIA, SANTA BARBARA (UCSB)

UCSB strives to be a leader in sustainability. UCSB and 300 other university presidents and chancellors spread across forty countries, signed the Talloires Declaration, committing to sustainable action. The Declaration is a ten-point action plan for promoting a sustainable, environmentally minded culture centered around teaching, research, operations and outreach (CSP, 2008).

Since signing the Declaration, UCSB has taken the lead in integrating sustainability into all aspects of its operations. In 2005, the Campus Sustainability Plan (CSP) developed the Campus Planning Committee. The plan is filled with goals, objectives and benchmarks from year 0 to year 20 (or 2028). To fulfill its sustainability goals, the campus sought specific objectives and sub-goals, including those targeted at procurement. These goals include: employing efficient procurement strategies, processes, and systems for the acquisition and responsible use of resources in a manner that supports a triple bottom line of economy, society, and environment (CSP, 2008).

The Chancellor's Campus Sustainability Committee was created to further UCSB's sustainability mission and achieve the goals outlined in the CSP. This committee provides oversight and guidance to subcommittees and working groups that strive to meet sustainability goals. Additionally, several student organizations assist in meeting these goals. In 2006, The Green Initiative Fund (TGIF) was created by students to "reduce the University's impact on the environment" by funding community sustainability projects, including this study. Another organization dedicated to further sustainability goals, LabRATS (Laboratory Research and Technical Staff) was founded to ensure sustainable laboratory practices and purchasing of laboratory products. Groups such as these can collaborate to improve campus-wide sustainable procurement. Figure 1 highlights the organizational structure of sustainability-related groups at UCSB.

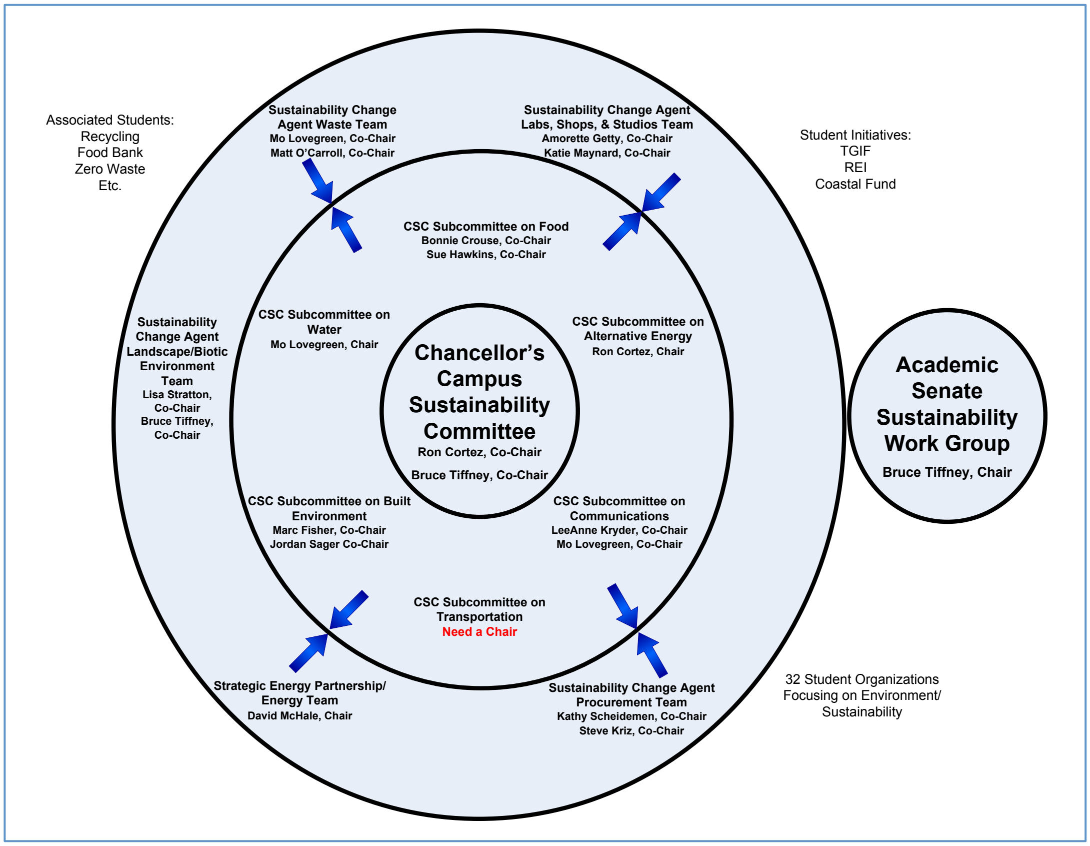

Figure 1: The levels of sustainability leaders and organizations at UCSB.
(Source: http://www.sustainability.ucsb.edu/wp-content/uploads/Visio-SustainabilityOrganization12_131.pdf)

PURCHASING AT UCSB

The UC system spends $2 billion annually on goods and services. UCSB expenditures account for $70 million of this total. Until 2013 purchasing was decentralized and data captured using several different accounting information systems. These various systems were used by myriad campus entities, from high-level procurement contracts to low-level, individual purchases overseen by the Purchasing Department. Campus facilities and housing departments are managed separately. Sustainable Purchasing Policies exist for some departments, but are not widespread. There is currently a gap in knowledge between the overall UCSB sustainability goals and department purchasers.

Purchasing is separated into several levels based on the amount spent. Departmental spending includes purchases below $2,500 and recently integrated into Gateway. For transactions under $2,500, department purchasers make buying decisions without oversight from the Purchasing Department on product sustainability. For purchases over $2,500, approval from the Purchasing Department is required and sustainability criteria can be considered to align with the CSP.

The Campus Sustainability Plan section on Purchasing targets sustainability measures for the following product categories:

- Office supplies
- Janitorial supplies
- Appliances, PCs, copiers, and fax machines
- ENERGY STAR products
- Carpet
- Furniture

One goal for office supplies is the requirement of a minimum of 30% post-consumer recycled paper, and to phase out all virgin paper products. Additionally, the CSP seeks to increase the number of environmentally friendly products available for purchase. Finally, the CSP goals aim to measure expenditures and set target benchmarks to efficiently reduce environmental impacts.

GATEWAY PROCUREMENT SYSTEM

Gateway, designed by the company SciQuest, was launched at UCSB in 2012 and phased into operation in 2013. Gateway is a user-friendly online procurement system through which department purchasers can search through campus vendor catalogs such as Office Max and Fisher Scientific. Gateway can be customized to allow EPPs, denoted by different sustainability criteria, to appear at the top of the search results. This encourages the purchase of EPPs. This system enables UCSB to track detailed information about product type, cost, and quantity that can allow for the establishment of a baseline of purchases in order to measure progress in achieving sustainability goals.

Currently in Gateway, sustainable items are marked with green flags and recycled content icons. Unfortunately, these indicators lack transparency and allow for false claims by vendors. The system allows for integration of other flags, such as UCOP-approved third-party certifications conveying that certain sustainability criteria have been met. Additionally, the purchase of certain items can be restricted within Gateway. To align with the UCOP policy to phase out virgin paper, all virgin paper products were recently restricted in Gateway, requiring approval from the Purchasing Department.

DATA

The data for this study were provided by the UCSB Purchasing Department. Data included purchases conducted by various departments over the 2011-12 fiscal year. In May and June 2012 electronic files containing purchase information for approximately $70 million were received. Over 90% of these data did not contain detail on the type of products purchased and therefore could not be analyzed. This was due to campus departments using different accounting systems, which primarily tracked transactions using generalized and highly aggregated descriptors. Therefore, of the numerous datasets of purchase information provided, only a small subset included product information with a level of detail adequate for analysis. Every data point used (13,640 transactions) needed to include a price and item description sufficient enough to allow it to be classified into a specific industry sector, otherwise referred to in this report as a product category. A product category in this context refers to a general type of product purchased. For example, a laptop computer would fall in the product category Electronic Computer Manufacturing. Because most of the data provided were unclassifiable, only 5.4% of the total campus expenditures were used for environmental impact assessment. An example of the usable data is shown below in Table 1. Vendor/manufacturer and item description were used to identify the appropriate product category for each product purchased.

Table 1: Example of purchasing data provided

Vendor/Manufacturer	Item Description	Item #		# items	$ Each	$ Total
Bill's Copy Shop	Black/White: 560 pages @ $.06 = $33.60		Each	1	33.6	33.6
Bill's Copy Shop	Color: 224 pages @ $.49 109.76		Each	1	109.76	109.76
Bill's Copy Shop	Coil Binding: 7 @ $3.99 = 27.93		Each	1	27.93	27.93
BKM	Table-capsule 36x72	BFK3672	Each	1	163.08	163.08
Canon USA, Inc.	Supply & maintenance of canon IR Advance 6055		Lot	1	648	648
CDWG	StarTech.com Latching SATA to Right Angle SATA Serial ATA Cable - Serial AT	1842089	Each	10	3.6	36
CDWG	Targus Laser Presenter Remote	1871474	Each	2	51.01	102.02
Crucial Memory	OptiPlex 990 Mini Tower Upgrade for a Dell Optiplex	CT1943281	Each	23	43.5	1000.5
DameWare Development	Dame Ware NT Utilities Single Version Upgrade	DNTUUPG1V	Each	2	57.8	115.6

SCOPE OF ANALYSIS

The scope of analysis focuses on the development of a framework to efficiently assess and reduce environmental impacts from campus purchases. Due to the lack of classifiable data, a sampling bias exists and this analysis is therefore not representative of all campus expenditures. Classifiable data of $3,765,299 comprised roughly 5.4% of total campus purchases, and included Central Stores, the Earth Research Institute (ERI), the Bren School of Environmental Science & Management, the Department of Psychology and Brain Sciences, and the Department of Geography.

Central Stores, the main provider of UCSB's office and cleaning supplies was analyzed, allowing for campus purchases of these products to be assessed and targeted for reduction. Other departments were analyzed to identify how high impact products vary by department. This allows for departments to target high impact products individually, in addition to the undertaking of campus-wide initiatives.

The recent implementation of Gateway has centralized campus purchases to one system, which will enable future studies on UCSB's expenditures to have a broader scope. Additionally, a survey was conducted with over 100 campus purchasers in order to identify barriers to and opportunities for increasing sustainable purchasing within Gateway. The scope of this project involved undertaking methods that compose a framework that can be followed by UCSB and other universities for future analyses, to assess and reduce environmental impacts from purchasing.

Finally, this report focuses on only one environmental impact category, global warming potential (GWP), which is one of many environmental impact categories that may be assessed in LCA. This decision was made to align with UC goals regarding climate change, but also to avoid the subjective weighting of each different type of environmental impact, which should be done by the University to most appropriately align with its sustainability goals and definitions.

PURPOSE OF METHODOLOGY

The main objective of this project was to develop a framework for UCSB to assess and reduce the environmental impacts that result from the procurement of goods and services. To most effectively improve the sustainability of its supply chain, this framework focused on the iterative process of assessment and action. By undertaking the steps highlighted in Figure 2 the University can analyze these environmental impacts across its supply chain, target areas for improvement, and implement strategies for reduction.

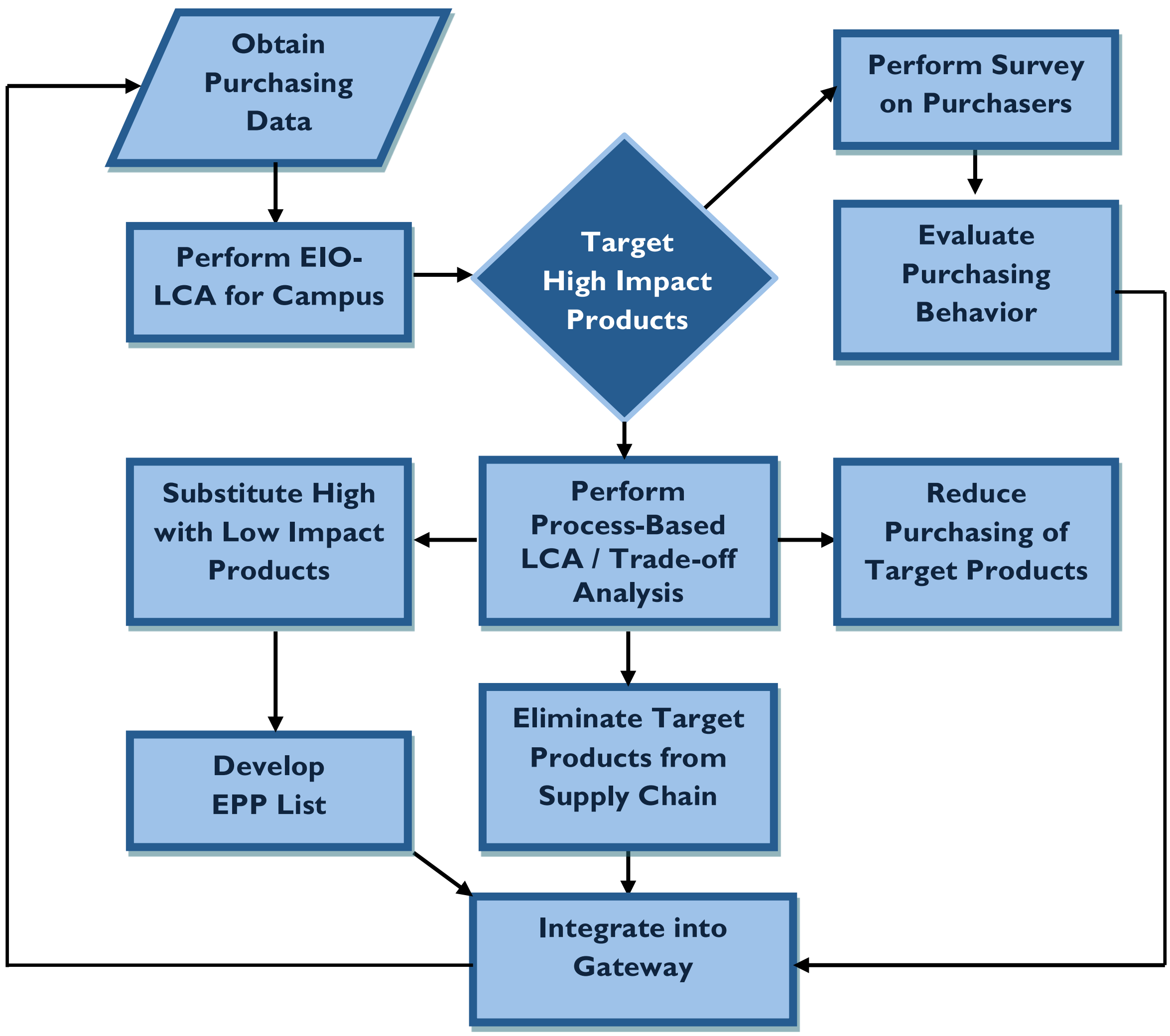

Figure 2: Smart Source Framework for Improving Sustainable Procurement. This is a process flow diagram of the framework illustrating the stages and decisions necessary for analyzing sustainable purchasing. Beginning with the obtainment of purchase data, an EIO-LCA can be conducted to determine target impact areas. At this point a decision regarding elimination (or restriction), reduction, or substitution of target products should be made. Product substitution might require a process-based LCA, and the development of a list of environmentally preferable products (EPP). A survey should also be conducted to determine opportunities and barriers to sustainable purchasing from a more operational and behavioral standpoint. The outcome of the decision, including the EPP list, and information gained from the survey results, can be integrated into the Gateway system. After this integration, more data may be obtained and the process repeated at a given interval in order to continually monitor sustainability.

PURPOSE OF EIO-LCA METHOD

A critical step in improving the sustainability of campus procurement is to develop a baseline assessment of the environmental impacts of its purchases. This is necessary to understand which products within the supply chain have the highest environmental impact. LCA quantifies the environmental impact of a product or service at each stage of its life cycle, including the extraction of resources, processing of materials, manufacturing, distribution, use, and waste management.

As UCSB's supply chain involves the purchase of a variety of goods and services across a multitude of economic sectors, a high level approach to LCA known as Economic Input-Output Life Cycle Assessment (EIO-LCA) was necessary for initial analysis. This method uses economic and environmental data to estimate environmental impacts of purchases (EIO-LCA is explained in greater detail in the EIO-LCA section). EIO-LCA allowed for the development of a baseline assessment and for the identification of purchases with the greatest contribution to UCSB's overall environmental impact. Both aspects are important components in the development of a sustainable procurement system, in order to measure and target areas for environmental impact reduction.

TARGETING IMPACT AREAS

Once a baseline assessment is performed and high impact products are identified, a more focused approach to reduce environmental impacts can be initiated. The next phase in improving sustainability along the supply chain is to target high impact products and develop measures to:

1. Eliminate targeted products from its supply chain;
2. Reduce the amount spent on targeted products; or
3. Substitute targeted products for lower-impact alternatives

DEVELOPING CRITERIA FOR ENVIRONMENTALLY PREFERABLE PRODUCTS

Given the time and resources, a process-based LCA is recommended in order to most effectively substitute lower-impact products for those with higher impacts. Process-based LCA can also analyze the impact of environmental tradeoffs that occur when product purchases are reduced or substituted for with other products. Additionally, process-based LCA is an ideal method for developing an EPP list. However, as process-based LCA can be both time-intensive and costly, the feasibility of this phase in developing an EPP list is limited. Other methods may be undertaken, in place of, or in conjunction with process-based LCAs, to create a functional EPP list within Gateway. Such methods include literature reviews and online process-based LCA models. While process-based LCA's have been shown to derive the most accurate information for individual products, the disadvantages may warrant the use of these alternate techniques.

Products can be weighted within Gateway so that when a buyer selects a product to purchase, environmentally preferable products rise to the top. In order to improve sustainable purchasing within Gateway, weights can be assigned to give priority in order of:

1. Products that meet UCOP preferred third-party certification criteria for sustainability;
2. Products that manufacturers self report as sustainable;
3. Products that are unreported as sustainable

SURVEY ANALYSIS OF UCSB PURCHASING BEHAVIOR

A survey was administered across campus to understand purchasing behavior at UCSB. By analyzing purchasing behavior, the procurement system can be modified to improve sustainable purchasing. Basic information sought from survey results included identification of purchasers and purchasing practices as they relate to environmentally preferable products. This phase of the framework allows for the development of strategies to encourage sustainable purchases in Gateway.

LIFE CYCLE ASSESSMENT (LCA)

BACKGROUND

All products and services have a life cycle, including the extraction of resources, processing of materials, manufacturing, distribution, use, and disposal/recycling, as well as transportation of the good or service. LCA measures the environmental impact of a product or service at each of the life cycle stages, accounting for all impacts from cradle to grave.

LCA is regarded across many industries as an acceptable method of evaluating the environmental impact of products and services as well as identifying emission and/or resource-intensive processes within a product system.

ISO & GENERAL LCA METHODOLOGY

The international organization for standardization (ISO) is a non-government federation of national standards bodies representing roughly 150 countries established with the task of facilitating "the international coordination and unification of industrial standards" (ISO, 2006).

ISO provides a general standardized methodology for conducting LCA: Within the ISO 14000 family of environmental management standards, ISO 14040, published in 2006, describes the principles and framework including each of the life cycle phases, the relationships between the phases, limitations of LCA, and provides LCA studies. ISO 14044, also published in 2006, enumerates the requirements and guidelines of LCA.

ISO defines LCA as the "compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product system throughout its life cycle" (ISO, 2006). A typical LCA, as outlined by the ISO 14040 framework, follows four phases:

Phase I - Definition of the goal and scope: Specifying the goal and scope clearly state the application, intended audience, the functional unit to be used, system boundaries, and data requirements, as well as breadth, depth, detail, and limitations of the study.

Phase II - Life cycle inventory (LCI) analysis: This phase involves compiling and quantifying all inputs and outputs of a product system through data collection and calculation. Data collection includes identifying all relevant materials, water, and energy used and any emissions to the environment, such as GHG's or the discharge of solid wastes. Data calculation involves validating collected data and relating data to unit processes and to the reference flow of the functional unit.

Phase III - Impact assessment: The goal of this phase is to evaluate the environmental impacts associated with the inputs and emissions identified in the inventory analysis. The process involves connecting inventory data to specific environmental impact categories and category indicators (e,g., global warming potential as indicated by kilograms of GHGs emitted).

An impact assessment consists of four steps:

1. Selecting and defining impact categories, category indicators, and characterization models
2. Classification: assigning LCI results to impact categories
3. Characterization: calculating category indicator results
4. Evaluating and reporting indicator results and LCIA results

Additionally, ISO states it may be desirable or necessary to include (prior to evaluation):

5. Normalization: expressing impacts in ways that can be compared
6. Grouping: sorting or ranking indicators
7. Weighting: emphasizing most important indicators

Phase IV - Interpretation: Findings from the inventory analysis and impact assessment are considered together in order to provide useful, informed information about the environmental impact of the studied products and processes. Results from this phase should be consistent with the goal and scope and should reach conclusions and recommendations.

ECONOMIC INPUT-OUTPUT LCA (EIO-LCA)

One method of performing LCA is through the use of economic input-output (EIO) tables. EIO-LCA is a high level, top-down, approach to LCA using industry-level economic and environmental data to estimate environmental impacts. These models use national EIO tables, which represent the monetary transactions among industry sectors across a nation's entire economy.

The input-output (IO) tables, or benchmark accounts, of the U.S are generated by the U.S. Bureau of Economic Analysis (BEA) every five years for years ending 2 and 7 (BEA, 2012). They represent the interrelationships among roughly 500 industries in the U.S. through the production and consumption of commodities by specifying the inputs that any sector of the economy needs from all other sectors to produce a unit of output (Hendrickson et al, 1998). Industry sectors are characterized using the North American Industry Classification System (NAICS), the standard used by federal agencies in collecting and analyzing economic data. A description of the EIO-LCA computation methodology is detailed in the Methodology section.

EIO-LCA calculates the cradle-to-gate impacts of products, not the entire life cycle. This means that it only considers the impacts of the creation of a product from resource extraction to product manufacture. It excludes the use and end of life phases of the product life cycle (Geyer, 2013). This limitation was acceptable for this project, as the project focused on purchasing and does not consider the use or end of life phases of the product life cycle.

Advantages and Disadvantages of the EIO-LCA approach are reflected in Table 2, shown below.

PROCESS-BASED LCA

Process-based LCA is typically considered the traditional form of LCA. Process LCA itemizes and calculates all inputs and outputs for a product within its system boundaries, determining the environmental impact of a product or product system through a bottom-up approach. Instead of using monetary units, it quantifies mass and energy flows through a product's supply chain, thus requiring an analysis of mass and energy balances. It is commonly referred to as the cradle-to-grave method, as it quantifies the entire life cycle of a product or product system, incorporating the use and end of life stages of a product or product system (Hendrickson et al., 2006).

Given the scope of this project, completing individual process LCA's for each product was impossible. After completing the EIO-LCA analysis and determining which product categories had the greatest environmental impacts, techniques were sought to explore process-based LCA's within those categories.

Advantages and disadvantages of the process-based LCA approach vary and include factors such as different levels of specificity, aggregation of data, uncertainty and many others, as shown below (Table 2).

Table 2: Advantages and Disadvantage of Process-Based LCA

	Process-based LCA	EIO LCA
Advantages	Results are detailed, process specific	Results are economy-wide, comprehensive assessments
	Allows for specific product comparisons	Allows for systems-level comparisons
	Identifies areas for process improvements, weak point analysis	Transparent: uses publically available and standard calculations for reproducible results
	Provides for future product development assessments	Provides for future product development assessments
		No system boundary: provides information on every commodity in the economy
		Tend to require less time and are cheaper
Disadvantages	Setting system boundary is subjective	Product assessments contain aggregate data
	Difficult to apply to new process design	Must link monetary values with physical units
	Use proprietary data	Imports treated as products created within economic boundaries
	Cannot be replicated if confidential data are used	Availability of data for complete environmental effects
	Uncertainty in data	Difficult to apply to an open economy (with substantial non-comparable imports)
	Tend to be time intensive and costly	Uncertainty in data: All data is compiled using surveys and forms submitted by industries to governments for national statistical purposes
		Linearity: the effects of purchasing $1,000 from one sector will be ten times greater than the effects of purchasing $100 from that sector
		Process assessments difficult
		Old data: data is representative of the year of the model
		Incomplete original data: original data in may be incomplete in that they underestimate actual values

* Source: CMU from Hendrickson, et al. 2006

TRADEOFFS AND OTHER DECISION MAKING STRATEGIES

A process-based LCA can help inform purchasers about whether restriction, reduction, or substitution of a product has the greatest effect on reducing environmental impacts. Other considerations include environmental tradeoffs that may result from any of these changes. If, for example, it is determined that reduction in paper use yields the greatest decrease in GHG emissions and the reduction is instituted, an increase in computer use might result. A further analysis can be done comparing computer use to paper use to determine the environmental consequences of replacement. Environmental tradeoffs usually exist when use of a product is reduced or the product is replaced. Attention to these environmental tradeoffs was beyond the scope of this project given the infeasibility of completing individual process LCAs for multiple products; however, a complete analysis can include process-based LCAs for both replacement and target products.

EIO-LCA METHODOLOGY

EIO-LCA uses input-output (IO) tables, which are aggregated economic sector level data, to quantify the amount of an environmental impact that can be attributed to each industry sector of the economy. These IO tables, or benchmark accounts, are created and presented by the US Bureau of Economic Analysis (BEA) in the form of make and use matrices and supplemental tables, including modified make and use tables and four requirements tables. Make matrices show the commodities produced by each industry while use matrices show the commodity purchases each industry makes in order to produce its output and the commodities consumed by end users (BEA, 2012).

The supplementary tables are make and use tables modified by redefining, or moving the inputs and outputs of some secondary products among industries. Redefinitions are made under a few scenarios: when the production process of a secondary product is significantly different than that of the industry's primary product; when different production processes are used to produce the same end product; when a product designated as a primary product should be a secondary product; or when a product is primary to more than one industry (BEA, 2012).

The requirements tables are derived from the supplementary tables. There are four types of requirements tables: commodity-by-industry direct requirements; commodity-by-commodity total requirements; industry-by-commodity total requirements; and industry-by-industry total requirements (BEA, 2012). The direct requirements table shows the amount of a commodity required by an industry to produce a dollar of the industry's output while the total requirements tables show the production that is required, directly or indirectly, from each industry and each commodity to deliver a dollar of commodity to end-users (BEA, 2012). EIO-LCA models then apply an additional calculation to one or more of the tables to generate another table suitable to the needs of an EIO-LCA model.

DERIVING AND CALCULATING IO TABLES

The interrelationships among industry sectors are complex as each relies on multiple suppliers across an economy. Suppliers are tiered from the perspective of any single producer. A simplified example is lemonade (Fig. 3). To produce lemonade, necessary inputs are lemonade and packaging. These inputs to the final product are outputs from the first tier suppliers. Next, to make lemonade, lemons, water, and sugar are required, and to produce the packaging, paper pulp and wax are needed. These inputs to the first tier suppliers are outputs from the second tier suppliers. If a third tier supplier were needed, the output from the third tier would be considered an input to the second tier supplier.

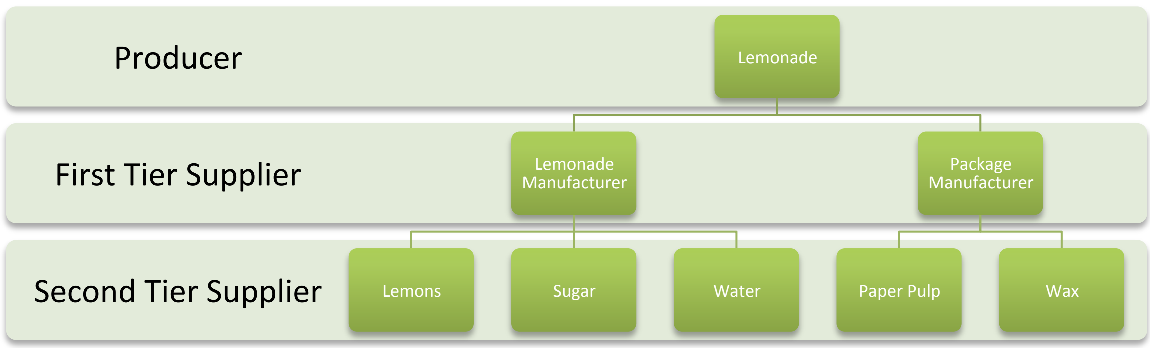

Figure 3: Example of supplier tiers for a lemonade producer.

The figure below is an example IO table in which columns and rows represent the same respective industrial sectors. This is called the technology matrix. The monetary amounts are the inputs required from each sector to produce $1 of output from the sector specified in the column. For example, $0.3 of input from sector e is required to produce $1 of output from sector a.

	a	b
a	$ 0.2	
b	$ 0.1	
c	$ 0.1	
d	$ 0	
e	$ 0.3	

Figure 4: Sample Input-Output Table. Column “a” lists the required amounts from each sector, a-e, to produce $1 from sector a. (Source: Geyer, 2013)

For every dollar of output for a producer, the required output from each first tier supplier can be determined, using matrix multiplication. Multiplying the technology matrix by the producer output matrix results in producer inputs required (Fig. 5).

Example 1

	a	b	c	d	e
a	$ 0.2				
b	$ 0.1				
c	$ 0.1				
d	$ 0				
e	$ 0.3				

x

Producer output
$ 1
$ 0
$ 0
$ 0
$ 0

=

Producer input
$ 0.2
$ 0.1
$ 0.1
$ 0
$ 0.3

= 1st tier suppliers output

$$A \times \vec{O} = \vec{I}$$

Figure 5: Matrix Multiplication of First Tier Supplier Output
Source: Geyer, 2013

The same process is used for second, third, etc. tier suppliers. Inputs for each producer are equal to the outputs of the next tier suppliers. Using matrix multiplication again, the required output from second tier suppliers to be used as inputs to first tier suppliers can be found (Fig. 6)

$$A \times A \times \vec{O}$$

	a	b	c	d	e
a	0.2	0.1	0	0.2	0.1
b	0.1	0	0.1	0.2	0.3
c	0.1	0.2	0.2	0	0
d	0	0.4	0.2	0	0.3
e	0.3	0	0.1	0.4	0

x

	a	b	c	d	e
a	0.2				
b	0.1				
c	0.1				
d	0				
e	0.3				

x

Producer output
1
0
0
0
0

=

2nd tier suppliers output
0.08
0.12
0.06
0.15
0.07

$$A \times \vec{O}_p = \vec{O}_1$$ input of producers = output of 1st tier suppliers

$$A \times A \times \vec{O}_p = \vec{O}_2$$ input of 1st tier suppliers = output of 2nd tier suppliers

Figure 6: Matrix Multiplication of Second Tier Supplier Output
(Source: Geyer, 2013)

To calculate the total economic output of all suppliers required to generate output for a given producer, the required outputs from each tier of suppliers through the nth tier are added, represented by the expression $(1 + D + D^2 + D^3 + D^4 \ldots)$ or $(1\text{-}D)^{-1}$, and multiplied by the producer output O_p. The result is the total output for all suppliers required to generate the producer output, $O_{Total,}$ modeled by:

$$(1 + D + D^2 + D^3 + D^4 \dots) * O_P = O_{Total}$$

To calculate the environmental impact associated with the producer output, an IO table is then associated with non-economic data such as an environmental intervention matrix. Interventions may include greenhouse gases, criteria air pollutants, water consumption, or toxic emissions, among others. O_{Total} is multiplied by the intervention matrix, R, to give the resulting intervention per dollar of output by sector:

$$R * (1 - D)^{-1} * O_P = R * O_{Total} = E$$

COMPREHENSIVE ENVIRONMENTAL DATA ARCHIVE (CEDA)

The Comprehensive Environmental Data Archive (CEDA) is considered a hybrid approach to LCA by combining the strengths of process and EIO-LCA. It was used in this study to compute the EIO-LCA and determine the product categories with the potential to cause the greatest environmental impacts. The following description and explanation of CEDA, its procedure, compilation of data, data sources, and derivation of its environmental matrix are adapted predominantly from Suh (2010).

CEDA can assist LCA by combining economic data with environmental interventions such as the use of natural resources and emissions to air, water, and soil. CEDA quantifies resource use and emissions by connecting EIO tables with a comprehensive list of environmental interventions.

CEDA was developed around the year 2000 at the Institute of Environmental Sciences at Leiden University with the initial intent of acting as an LCI reference for process LCA's, called the Missing Inventory Estimation Tool (MIET). The first version of MIET was released in 2001 using data from the 1996 U.S. input-output table and environmental statistics. An updated version was released in 2002 with improved algorithms and extended coverage of environmental interventions. In 2003 it was updated again, using 1998 data and renamed CEDA 3.0, covering 480 products and 1,344 environmental interventions, including 44 GHG's.

The most recent version, CEDA 4.0, was released in 2009 using input-output tables and environmental statistics from 2002 and is the most comprehensive version thus far. This is due to three major upgrades: the capability to choose between economic allocation or system expansion in assigning environmental interventions to an economic category; an increase in the number of environmental interventions to more than 2,500 in the U.S. version, including consumptive water use, total fossil energy consumption, and emission of 17 different dioxins; and the ability of allowing users the option to exclude capital goods in the supply chain.

CEDA OVERALL PROCEDURE

Data compiled within CEDA are retrieved from multiple sources as much as possible in order to provide the most accurate calculations possible. In instances where the necessary data are not available, the data is modeled using activity data or some other proxy data for the respective emission (Suh, 2010).

After data sets are compiled, they are validated by two methods. Data are first compared by category. If two data sets of the same quality show a significant difference and a reason for the difference cannot be provided, additional data is acquired to explain the difference or replace it. Second, the data are aggregated to a scale useful for comparison with other available national statistics and are again compared with respective statistics, following the same approach (Suh, 2010).

Further aggregation may still be needed, such as per source category or per fuel category. These data are aggregated per substance per compartment and paired with the input-output data. The resulting data sets are then ready for LCI calculation (Suh, 2010).

CEDA COMPILATION OF INPUT-OUTPUT DATA

CEDA 4.0 uses the 2002 input-output tables produced by the U.S BEA, in the form of make and use matrices. The matrices are compared before and after redefinition in order to identify redefined flows (such as a product secondary to one sector reassigned to another sector to which it is the primary product). Those flows are used to generate an IO table by reproducing the mixed-technology approach utilized by the BEA. This method uses a combination of economic allocation and system expansion (mixed-technology approach). Another IO table is also produced based only on economic allocation. For both allocation methods, the resulting final matrix is a commodity-by-commodity table called the Direct Requirement Matrix, or Matrix A. Users may opt to use either allocation method, economic allocation (industry-technology) indicated by the letter a, or economic allocation and system expansion (mixed-technology model) indicated by the letter b (Suh, 2010).

The terms economic allocation and system expansion represent the techniques used to address the issue of allocation in the LCI stage of LCA. In this context, allocation refers to the practice of assigning quantities of the inputs and outputs of a multiproduct process to each of the products generated. Economic allocation assigns proportional value of the inputs and outputs to each product while system expansion widens the primary product system to include the functions of all products. The objective of both methods is to condense systems with multiple output processes to systems of single output processes (Suh et al, 2010).

CEDA ENVIRONMENTAL DATA SOURCES

CEDA 4.0 contains environmental data accessed from a number of various databases, depending on the environmental impact category (Table 3):

Table 3: CEDA Environmental Data Sources

Type of Data	Units of the Matrix Elements	Source of Information	Year of Publication
Greenhouse gas emissions	Trillion Btu	Energy Information Administration – 2002 Energy Consumption by Manufacturers, Data files	2005
	Tg CO_2 Eq. or million metric tons CO2 Eq.	Environmental Protection Agency - Inventory for US GHG Emissions and Sinks: 1990-2002.	2004
Toxic Releases	Quantities of dioxin and dioxin-like compounds are reported in grams; all other chemicals are reported in lbs.	EPA – *Toxics Release Inventory*	N/A
	Thousand short tons	EPA - *National Emission Inventory*	N/A
	Lbs or lbs/acre	NASS – *Agricultural Statistics*	2008
		USDA – *Agricultural Waste Management Field Handbook, National Engineering Handbook (NEH) Part 651*	2000
	Tons/acre	USDA – Model Simulation of Soil Loss, Nutrient Loss, and Change in Soil Organic Carbon Associated with Crop Production	2006
Agrochemicals	Tons/year	EPA – *Emissions Factors and AP 42, compilation of Air Pollutant Emissions Factors, Chapter 9: Food and Agricultural Studies*	1995
	Lb/acre	NASS – *Agricultural and Chemical Use Data*	2009
	Lbs applied	NCFAP – *Pesticide Use in the US Crop Production*	2000
	Pounds of pesticides applied; Leaching mass loss, pounds; Dissolved runoff mass loss, pounds; Adsorbed runoff mass loss, pounds	USDA – Natural Resource and Conservation Service, Environmental Indicators of Pesticide Leaching and Runoff from Farm Fields	2000
Primary Energy Consumption and Other Resources Data Compilation	Million metric tons of usable ore	EIA – *Statistics for Natural Gas, Petroleum and Coal in the US, Data Files*	2009
		USGS – *Mineral Information: Iron Ore*	2009
	Million cubic feet harvested	USDA – *Estimated Timber Harvest by US Region and Ownership, 1950-2002*	2006
Land Use Change	Million acres used for given purpose	USDA - *Major Uses of Land in the United States 2002*	2005
Water Use	Mgal/day	USGS – *Estimated Use of Water in the US in 2000*	2004
	Mgal/day	USGS – *Estimated Use of Water in the US in 2005*	2009
Waste	Tons generated	EPA – *The National Biennial RCRA hazardous waste report*	2005
		EPA - *Sustainable Materials Management: The Road Ahead*	2009

Source: Suh (2010) from Eaton et al. (2011)

CEDA DERIVATION OF ENVIRONMENTAL MATRIX

Because the input-output (Matrix A) part of CEDA uses a commodity-by-commodity matrix, the environmental intervention data is compiled in an intervention-by-commodity matrix, Matrix B. This table gives units of the respective environmental intervention per dollar. Matrix B is based on the equation:

$$m = B^I\,(I - A)^{-1}y$$

Where:

- B^I = environmental intervention-by-industry matrix representing the environmental interventions caused by one dollar worth of industry output
- A = commodity-by-commodity input-output technology coefficient matrix
- y = final demand vector
- m = total economy-wide environmental intervention

Information on environmental interventions is compiled mainly by industry rather than by product (Suh, 2010). Therefore, an environmental intervention-by-commodity matrix is derived from B^I by assigning the aggregate environmental intervention for each industry to the primary and secondary products, as well as scrap (Suh, 2005). Because CEDA 4.0 allows users to assign intervention using either economic allocation (also known as the industry-technology approach) or a combination of economic allocation and system expansion (also known as the mixed technology method), average environmental intervention per dollar is calculated using both methods.

In the industry-technology approach, the sum total of environmental interventions is assumed to be assigned proportionally to primary and secondary products based on their economic value. Average environmental intervention per dollar of commodity is calculated on the basis of market share as:

$$B = B^I D$$

Where:

- B^I = environmental intervention by industry matrix representing the environmental interventions caused by the production of $1 worth of industry output
- D = a market share matrix derived from make-and-use matrices
- B = an environmental intervention-by-commodity matrix

Matrix B in CEDA was constructed using this method.

Under the mixed-technology approach, each product is assumed to generate its own characteristic environmental interventions, regardless of the industry producing it. The total environmental intervention of a primary product is calculated by subtracting the total environmental intervention due to secondary products. The interventions from secondary products are assigned to industries producing the secondary products as primary products (Suh, 2005). CEDA 4.0 uses this method in combination with the industry-technology approach to produce a matrix based on both approaches.

Just as with the input-output data, each approach is indicated by a (industry technology approach) or b (mixed technology model).

TOOL FOR THE REDUCTION AND ASSESSMENT OF CHEMICAL AND OTHER ENVIRONMENTAL IMPACTS (TRACI)

Both CEDA and the Carnegie Mellon University's (CMU) EIO-LCA models use the Tool for Reduction and Assessment of Chemical and other environmental Impacts (TRACI) to quantify the Life Cycle Impact Assessment (LCIA) results. In this phase, impact categories are determined and assigned to Life Cycle Inventory (LCI) results based on the goal and scope of the study. This project focused on global warming potential from greenhouse gas emissions, as it aligned with UC-wide sustainability goals (UC Sustainable Practices Policy, Section III - C). Global warming potential is also the most scientifically valid and defendable impact category within LCA (Geyer, 2013).

After attaining direct and indirect total cradle to gate LCI per dollar results with the steps outlined in the previous section, they are characterized using TRACI. For GWP, greenhouse gas emissions per dollar are aggregated to the impact category using scientifically based characterization factors. Characterizing the LCIs to one impact category allows for comparison between industries. For example, the product category "paper mills" can be compared to "electronic computer manufacturing" in terms of their contribution to global warming potential.

Impact modeling techniques for the LCIA phase include end-point and mid-point modeling. End-point modeling quantifies the environmental damage, defined in the ISO 14040 standards as an "attribute or aspect of natural environment, human health, or resources, identifying an environmental issue giving cause for concern" (ISO, 2006). Polar melt, longer seasons, and soil moisture loss are examples of a characterization end-point for climate change (SAIC, 2006). Mid-point modeling quantifies the relative potency of the environmental stressors at a mid-point within the cause-effect chain (Bare, 2003). A chemical's radiative forcing and lifetime are examples of climate change's mid-point category (Bare, 2003). Examples of mid-point versus end-point modeling mechanisms for TRACI's impact categories are shown in Appendix 1. Mid-point modeling is more reliable, minimizing the need for forecasting and assumptions (SAIC, 2006).

The US Environmental Protection Agency (EPA) utilized a mid-point approach in developing TRACI. This LCIA tool models the characterization of potential environmental impacts for the following categories: ozone depletion, global warming, acidification, eutrophication, tropospheric ozone (smog) formation, ecotoxicity, human particulate effects, human carcinogenic effects, human non-carcinogenic effects, fossil fuel depletion, and land use effects (Bare, 2003). The modular approach TRACI uses allows for integration of new scientific data, allowing the model to be easily updated. TRACI was first launched in 2002, and new data for several impact categories led to the release of TRACI 2.0 in 2010 (Bare, 2011). TRACI and TRACI 2.0's strengths include the scientific research behind it, its consistency with regulations and policies, and its versatility (Bare, 2003). CEDA uses both TRACI and TRACI 2.0 to quantify the environmental impacts for various categories.

TRACI: CLIMATE CHANGE/GLOBAL WARMING POTENTIAL

Greenhouse gases (GHG) built up in the atmosphere warm the earth by trapping heat from the reflected sunlight that would have otherwise passed out of the earth's atmosphere (Bare, 2003). Based on TRACI's midpoint modeling, climate change is defined as the impact of anthropogenic emissions on the radiative forcing of the atmosphere (Guinee, et al., 2002). An example of GHGs in this category include: carbon dioxide (CO_2), nitrogen dioxide (NO_2), methane (CH_4), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and methyl bromide (CH_3Br). TRACI uses global warming potentials and the 100-year time horizon recommended by the Intergovernmental Panel on Climate Change (IPCC) to quantify the potency of GHGs, relative to a CO_2 equivalent (Bare, 2003). For example, methane's global warming potential for a 100-year time horizon is relative to 1 kg CO_2, so it equals 25 kg CO_2 equivalent. This means that if the same mass of methane and carbon dioxide are released in the atmosphere, methane will trap 25 times more heat than carbon dioxide over a timespan of 100 years.

To model global warming potential, TRACI calculates the sum of the emissions from a GHG times its GWP, expressed as the global warming potential index (Bare, 2003). The global warming potential index expresses the ratio between the radiative forcing of the GHG over the radiative forcing of an equivalent unit of CO_2, both integrated over time. This equation is:

$$GWP_{T,i} = \frac{\int_0^T a_i c_i(t)dt}{\int_0^T a_{CO_2} c_{CO_2}(t)dt}$$

Where

- a_i is the radiative forcing per unit concentration increase of greenhouse gas *i* ($w*m^{-2}*kg^{-1}$)
- $c_i(t)$ is the concentration of greenhouse gas *i* at time *t* after the release ($kg*m^{-3}$)
- *T* reflects the time over which the integration is performed (yr) (Guinee, et al., 2002)

Significant amounts of research support its methodology and scientific basis (Geyer, 2013).

CARNEGIE MELLON UNIVERSITY EIO-LCA TOOL (CMU)

The Carnegie Mellon University EIO-LCA tool (CMU), developed by the Green Design Initiative, also uses EIO models to analyze environmental impacts. For this project, the CMU tool was used to validate and compare results obtained using CEDA. Both EIO methods rely on data provided by the U.S. Bureau of Economic Analysis that is based on two assumptions:

1. There is a linear relationship between the outputs of a production facility and all the inputs that facility uses for production.
2. All production facilities that are used to make products and services can be aggregated into roughly 500 sectors (Hendrickson et al., 2006).

As with CEDA, the CMU tool uses NAICS-based IO codes for each of the aggregated sectors. In order to calculate GHG emissions for the IO sectors, the CMU tool uses direct estimation of GHG emissions from fossil fuel combustion, and other public EPA data for non-fossil fuel combustion (Weber et al., 2009). The CMU tool also uses TRACI methodology to characterize global warming potential.

PROCEDURE FOR UCSB EIO-LCA USING CEDA 4.0

To use CEDA 4.0, the data provided by UCSB needed to be sorted and individual products clearly identified. Because the data did not contain standardized information on product type, item descriptions and vendor names for each of the roughly 14,000 line items were used to identify each product purchased. Each group member was tasked with sorting through a department's purchase report and identifying the product type for each transaction. The second step was organizing the data to be compatible with CEDA. CEDA assigns environmental impacts by IO codes, which are based on NAICS. While many of the IO codes are similar to NAICS, CEDA aggregates the 1,100 NAICS codes into roughly 430 IO (product category) codes. A subset of the acquired UCSB purchasing data was grouped into product categories and labeled with appropriate IO codes. Each IO code was assigned based on information from the US Census NAICS website and a NAICS to IO code conversion sheet. For example, laptop computers would be assigned IO code 334111 – electronic computer manufacturing, while copy paper would be assigned IO code 322120 – paper mills.

Next, multiple conversion factors had to be applied to the data. Because CEDA 4.0 uses economic data from 2002 and UCSB purchasing data were from 2011-12, the data needed to be converted to 2002 dollars. CEDA 4.0 provides inflation-deflation factors based on data generated by the BEA for years 1998 through 2009. The factors are based on detailed estimates underlying GDP-by-industry accounts (CEDA 4.0 Inflation-Deflation Factors 1998-2009). The factors are compiled by IO code to correspond to each industry category. The 2009 factors were used as a proxy for the current year (2011-12) since it was the most recent data available in CEDA. The appropriate deflation factor was determined as:

$$\frac{2002\ Factor}{2009\ Factor} = Deflation\ Factor$$

The dollar total for each CEDA category was multiplied by the respective deflation factor, resulting in the 2002 price.

The second conversion was from purchaser (consumer) to producer price. Producer price can be found by subtracting retail markup, wholesale margin and transportation cost from the purchase (retail) price (CEDA 4.0). CEDA 4.0 uses producer prices because they are more homogenous and more stable over time than purchaser prices (CEDA 4.0). CEDA provides the appropriate factors by IO code in its Purchaser Price to Producer Price conversion factor database, which are also based on data from the BEA. The database provides two tables: one provides purchaser to producer price conversion factors between the purchasing sector and the sector purchased from; the other provides average factors based on the product purchased. The average factor was used for this project. In order to convert to producer price, the total expenditure for each IO code, in 2002 dollars, was multiplied by the appropriate conversion factor. The result provided the total expenditure by sector in 2002 producer price.

The final step involved multiplying total expenditure by the TRACI environmental intervention factors in CEDA. As described above, the factors are provided with the option of using version A, which is based on economic allocation only (industry-technology approach) or version B, based on economic allocation and system expansion (mixed technology model). For each IO code the twelve characterization factors within TRACI were multiplied by the total expenditure for the corresponding IO code, resulting in the formula:

$$\begin{aligned} &Environmental\ Impact \\ &\quad = Total\ expenditure * \left(\frac{\mathbf{2002}}{\mathbf{2009}} price\ conversion\right) \\ &\quad * Purchaser\ to\ Producer\ Price\ Conversion \\ &\quad * TRACI\ Characterization\ Factor \end{aligned}$$

The calculations were performed in Microsoft Access by relating the purchasing data and CEDA databases. All of the purchasing data collected from UCSB and the CEDA databases were imported into Access and queries were used to reference the appropriate tables in order to automate the calculations.

The final environmental impact categories (and units) are highlighted below:

- Global Warming Potential – kg CO_2eq.
- Acidification – H+ moles eq.
- Eutrophication – kg N eq.
- Water Consumption – kg
- Primary Energy Consumption – thousand BTU
- Human Health Criteria Air Pollution – kg PM10 eq.
- Ozone Air Depletion – kg CFC-11 eq.
- Smog Formation – kg O_3eq.
- Eco-toxicity – CTUE (Comparative Toxic Units ecotox)
- Human Health cancerous – CTUH (Comparative Toxic Units health)
- Human Health non-cancerous – CTUH (Comparative Toxic Units health)
- Land Use – acres

PROCEDURE FOR UCSB EIO-LCA USING CMU

As with CEDA, the CMU tool combines LCA with EIO data to analyze a variety of direct and indirect environmental impacts that result from purchasing goods or services within each sector. This project used the TRACI Impact Assessment category for global warming (in kg of CO_2 equivalents). CMU also uses the 2002 producer price and nearly identical IO code aggregation to CEDA. Therefore, 2002 prices and IO coding were kept consistent for both CEDA and CMU analyses. Expenditure for each product category was entered into the tool in 2002 producer price, generating LCA results using TRACI. The results from the CMU model for GWP were compared with CEDA to gauge the accuracy of the findings.

While GWP was the only environmental impact described and analyzed throughout this report, results for several other environmental impact categories were calculated and may be used by the University to determine the sustainability of specific product types. These results are contained in Appendices 2, 3, and 4, and the process of using this information will be discussed further in the recommendations section.

RESULTS & DISCUSSION FOR UCSB EIO-LCA

TOTAL BREAKDOWN OF LCA FOR GWP

The overall results using CEDA show that in most cases, environmental impact is highly correlated with the amount of money spent. The correlation between expenditure and GWP for the categories analyzed in this report is 96% and the average correlation between expenditure and each of the twelve TRACI impacts is 93%.

The total expenditure for all purchases analyzed through CEDA was about $3,765,300, resulting in a total estimated GWP of 1.86 million kilograms of carbon dioxide equivalent (kg CO_2eq). Of that, Earth Research Institute (ERI) constituted the highest proportion of expenditures at over 58% and Central Stores had the second highest, with just over 20%. These departments had the greatest impacts in every TRACI impact category. Results for all impact categories are displayed in Appendix 2. The contribution of each department can be analyzed in terms of total expenditure and total GWP impact (Table 4 and Fig. 7).

Table 4: Department contribution of expenditure and GWP

Department	Expenditure	Percent of Total Expenditure	GWP (kg CO2eq)	Percent of Total GWP
Central Stores	$757,035	20%	678,900.43	36%
Bren School	$175,152	5%	123,176.62	7%
Earth Resource Institute	$2,204,143	59%	766,414.78	41%
Geography	$568,284	15%	252,083.47	14%
Psychology and Brain Sciences	$60,684	1%	41,038.81	2%
Total	**$3,765,299**	**100%**	**1,861,614**	**100%**

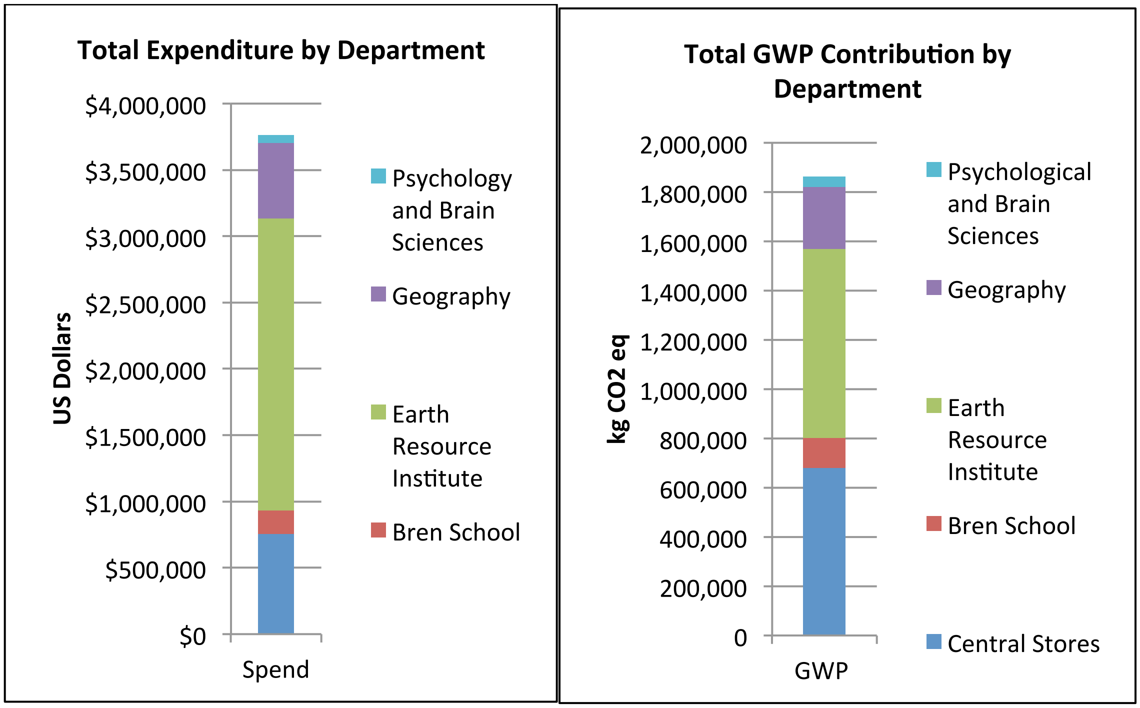

Figure 7: Total expenditure and total GWP contributed by each department

The proportional impact displayed in Figure 7 trend across all twelve environmental impact categories, illustrating the importance that total expenditure has on environmental impact. Figures for all impact categories by department are located in Appendix 3.

Of the 183 product categories included in the CEDA analysis, ten product categories made up 74% of total GWP (Table 5). The top four product categories – electronic computer manufacturing, scientific research and development services, sanitary paper product manufacturing, and paper mills – made up 56% of the overall GWP, the remaining 6 of the top 10 only contribute 18%. Of these top four categories, paper mills have the highest GWP per dollar. Outside the top ten categories the remaining 173 categories contribute 26% of the total GWP (Figure 8). This emphasizes the importance of determining and targeting the areas of greatest impact.

Table 5: Product Categories Ranked by Contribution to Global Warming Potential					
IO CODE	**Product Category**	**Environmental Impact (kg CO2 eq)**	**Dollar Amount Spent**	**Environmental Impact per Dollar (kg CO2 eq/$)**	**Percent of Total GWP Emissions**
334111	Electronic computer manufacturing	332,573.480	$300,532.02	1.1066	17.9
541700	Scientific research and development services	252,576.189	$1,005,899.08	0.2511	13.6
322291	Sanitary paper product manufacturing	235,986.738	$261,369.47	0.9029	12.7
322120	Paper mills	225,321.386	$191,641.63	1.1757	12.1
334220	Broadcast and wireless communications equipment	77,475.390	$227,761.90	0.3402	4.2
339111	Laboratory apparatus and furniture manufacturing	64,481.989	$233,517.85	0.2761	3.5
325610	Soap and cleaning compound manufacturing	63,840.603	$99,377.91	0.6424	3.4
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	42,458.027	$45,233.76	0.9386	2.3
325188	All other basic inorganic chemical manufacturing	38,242.214	$24,266.85	1.5759	2.1
33411A	Computer terminals and other computer peripheral equipment manufacturing	37,981.180	$65,467.33	0.5802	2.0
	All other product categories	490,676.90	$2,455,067.80	-	26.4
	Total	**1,861,614.096**	**$4,910,135.60**	**7.7897**	**100.0**

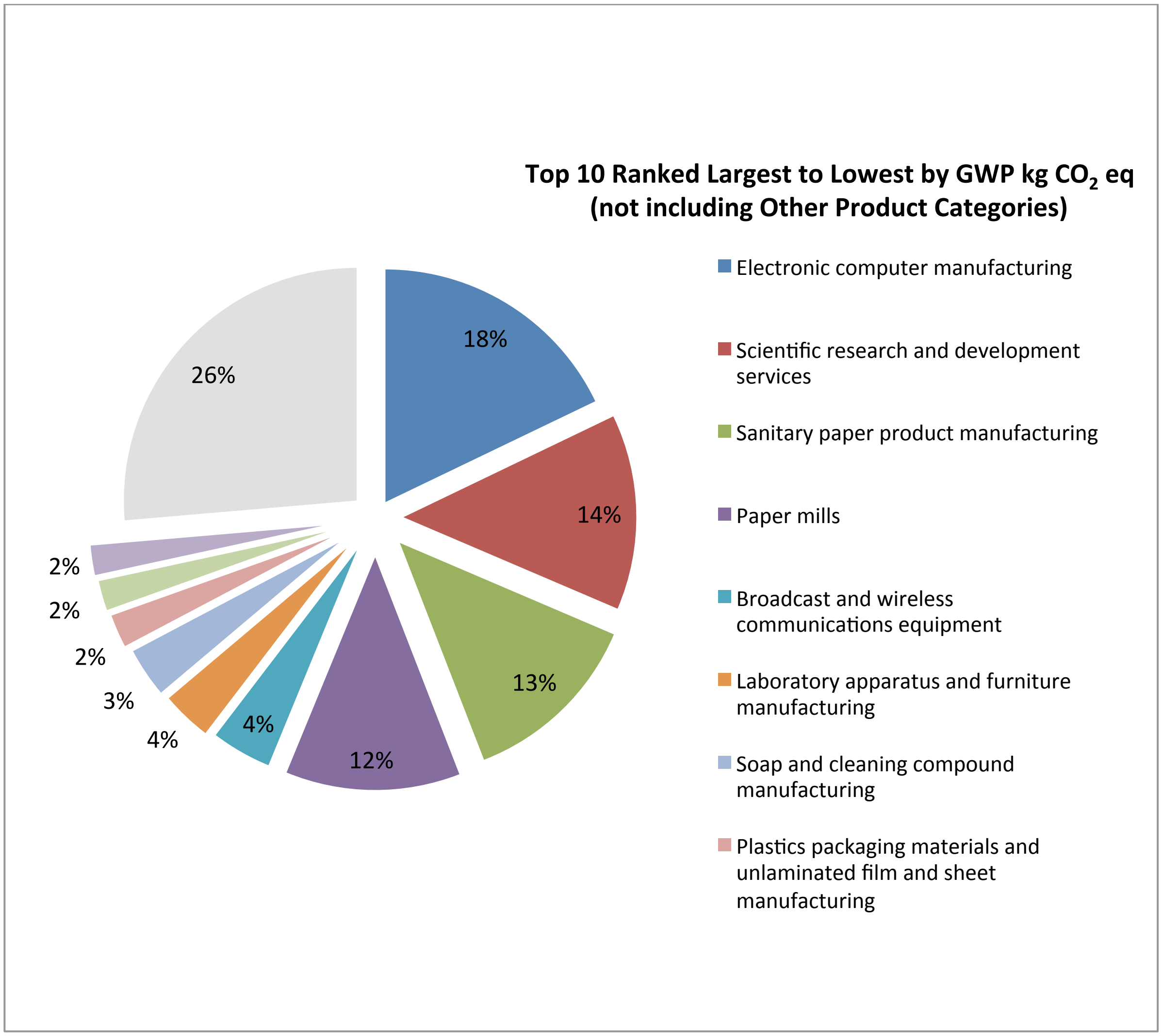

Figure 8: The relative contribution of each of the top ten product categories. It is important to note, while 'all other product categories' make up the largest portion, the group is comprised of 173 product categories lumped together, each of which make up only a fraction of a percent of the total GWP.

In order to determine how much of these product categories were purchased by each department in the sample, the top ten product categories were expressed by department (Fig. 10). The number one contributor to GWP, electronic computer manufacturing, had similar contributions from the Bren School, ERI, and Geography, with a smaller portion from Psychology and Brain Sciences. Two of the top product categories, scientific research and development services and broadcast and wireless communications equipment, consist of only a few high value purchases made entirely within one department.

Paper products, including both sanitary paper products and paper mills (copy paper, letterhead, etc.), were purchased almost entirely by Central Stores. This also applies to soap and cleaning compounds, and plastics packaging materials and un-laminated film and sheet. However, as Central Stores provided general office and cleaning supplies to most of the UCSB campus, this accounted for a large proportion of the campus's purchasing of these products.

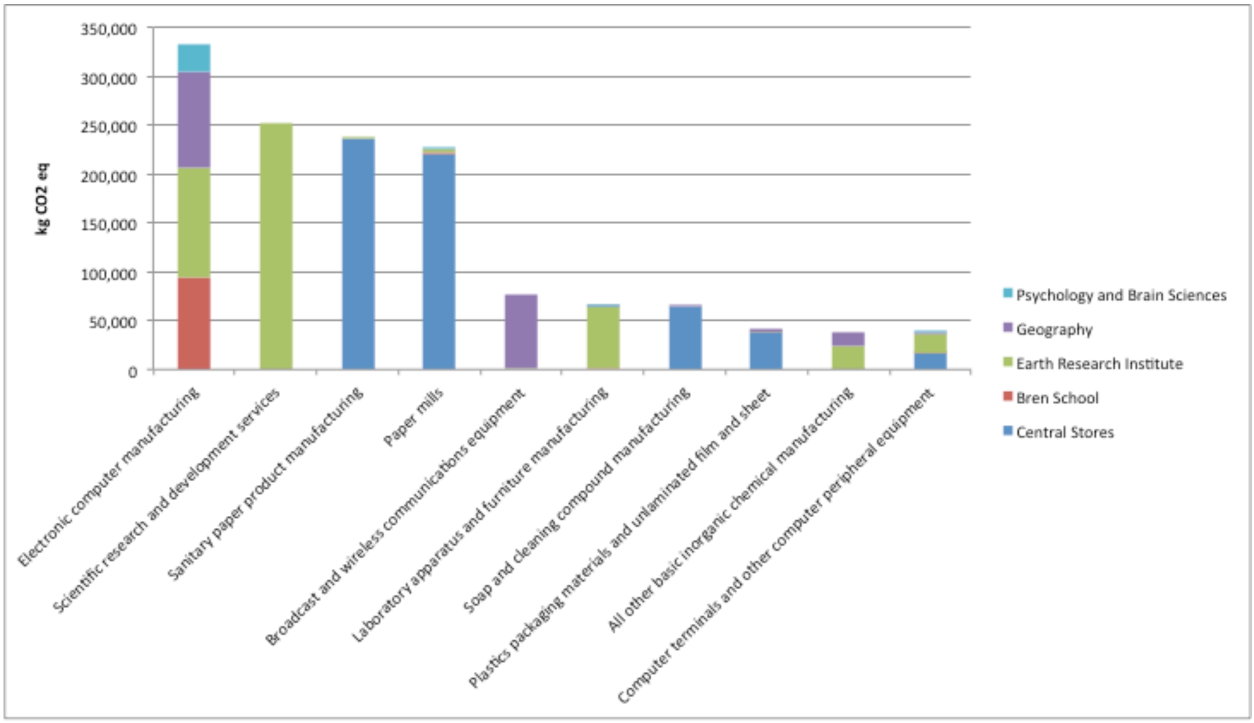

Figure 9: Departmental breakdown of the top ten product categories contributing to global warming potential

DEPARTMENTAL BREAKDOWN OF LCIA FOR GWP

After reviewing approximately 14,000 transactions and aggregating products into input output (IO) codes used by CEDA, results were generated for 4 academic schools or departments (departments) and Central Stores, the main purchasing agent for campus-wide office and cleaning supplies. These departments and Central Stores were analyzed for their effects on the environment from procurement activities. The Bren School, the Department of Psychology & Brain Sciences, the Department of Geography, ERI, and Central Stores were evaluated as they were part of only 11 departments for which line-item product data were available.

Breaking down the departmental contributions brings clarity to our total results and the sampling bias resulting from taking a subset of purchasing data from a large and diverse institution such as UCSB. While categories from Central Stores represent half of the product categories that compose the overall top ten, these categories represent a small proportion of departmental contributions (Fig. 10). Office paper products (coded as paper mills) were found to result in 33% of the total GWP from Central Stores purchases, and 12% of the overall total for the 5 departments. However, when reviewing each department's GWP, paper mills was found in only one department's top ten, the Bren School, at 6% of its overall GWP impacts. This is due to Central Stores selling office and cleaning supplies to a large proportion of departments on campus.

These results are important to both inter-departmental efforts towards improving sustainability, and to capture an accurate picture of the high GWP-impact product categories. By understanding which products are the largest contributors to GWP, departments can make internal decisions on how to best target and reduce their adverse effects on the environment. Upon analysis of the results, there are differences between departments for which product categories have the greatest proportional impacts. Therefore, strategies and efforts to reduce these impacts may differ depending on the products that the departments can aim to eliminate, reduce or substitute from its supply-chain.

This highlights the need for a centralized purchasing system that can capture product information and code product types for complete and accurate data campus-wide. Additionally, these results speak to the variations in purchasing across departments. Information on environmental impacts at the departmental level can allow for initiatives to be taken within departments to reduce their footprint. This can be done in conjunction with campus-wide targeting and successful utilization of Gateway. Below are the breakdowns by department of the top ten product categories for GWP in kg of CO_2 equivalent.

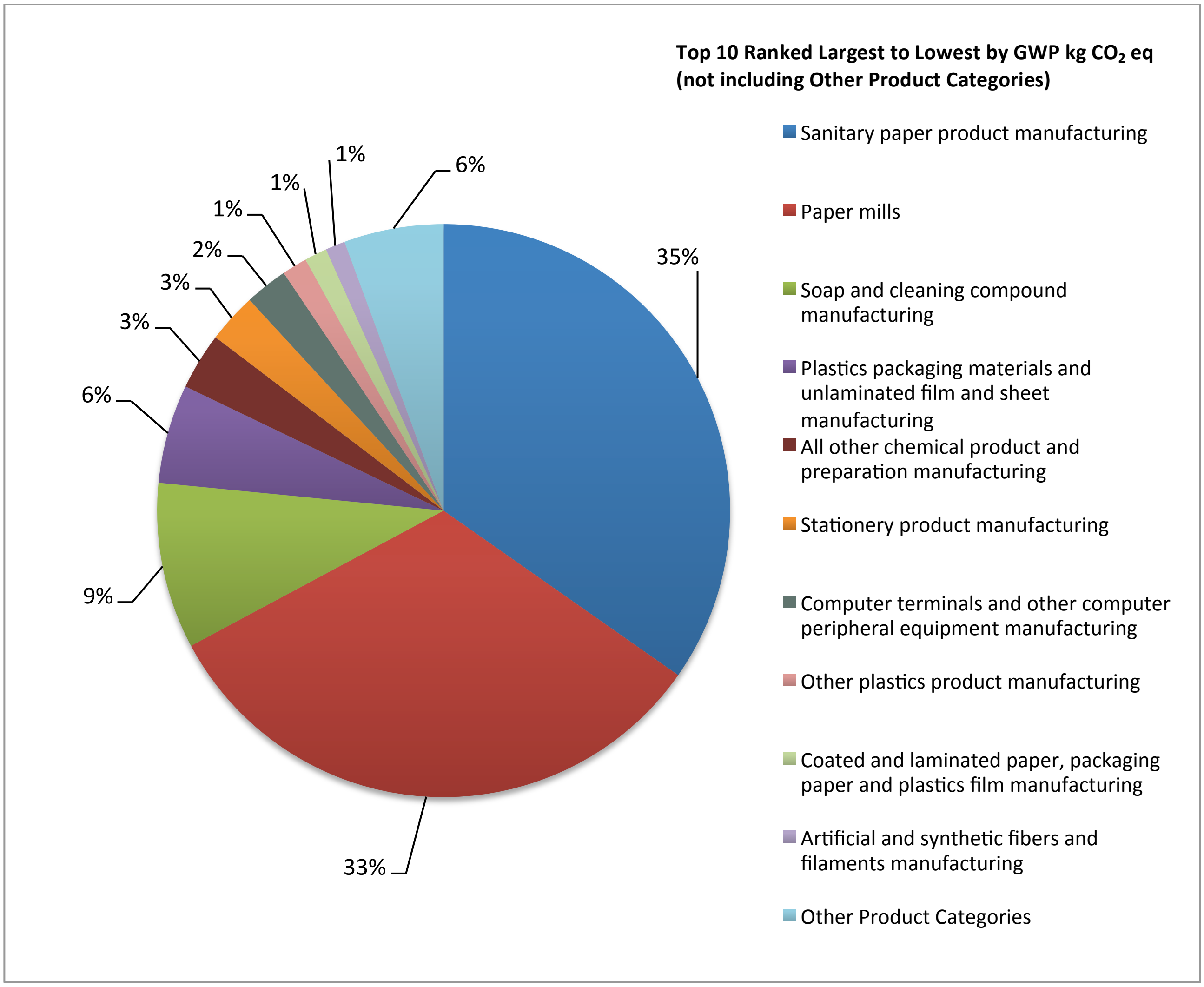

Figure 10: Central Stores Top 10 Product Categories for Global Warming Potential (in kg CO_2 equivalent)
For all 2011-12 transactions that totaled $757,035, Central Stores had 56 product categories that were measured using CEDA for GWP. Overall these categories were found to emit 678,900 kg of CO_2 eq through the production life cycle. Other Product Categories represent the sum of the remaining 46 product categories outside the top 10. Other Product Categories represent $51,615 in transactions and 38,205 kg of CO_2 eq.

Table 6: Central Stores Life Cycle Impact Assessment - Global Warming Potential					
IO Code	**IO Code Description**	**Impact Subtotals (kg CO2 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	235,808	$261,172	0.9	35%
322120	Paper mills	220,280	$187,354	1.18	33%
325610	Soap and cleaning compound manufacturing	63,641	$99,068	0.64	9%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	37,883	$40,360	0.94	6%
3259A0	All other chemical product and preparation manufacturing	21,791	$28,351	0.77	3%
322230	Stationery product manufacturing	19,073	$30,907	0.62	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	16,421	$28,305	0.58	2%
32619A	Other plastics product manufacturing	9,649	$11,704	0.82	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	8,638	$13,488	0.64	1%
325220	Artificial and synthetic fibers and filaments manufacturing	7,511	$4,712	1.59	1%
	Other product categories	38,205	$51,615	0.74	6%
TOTALS:		**678,900**	**$757,035**	**0.90**	**100%**

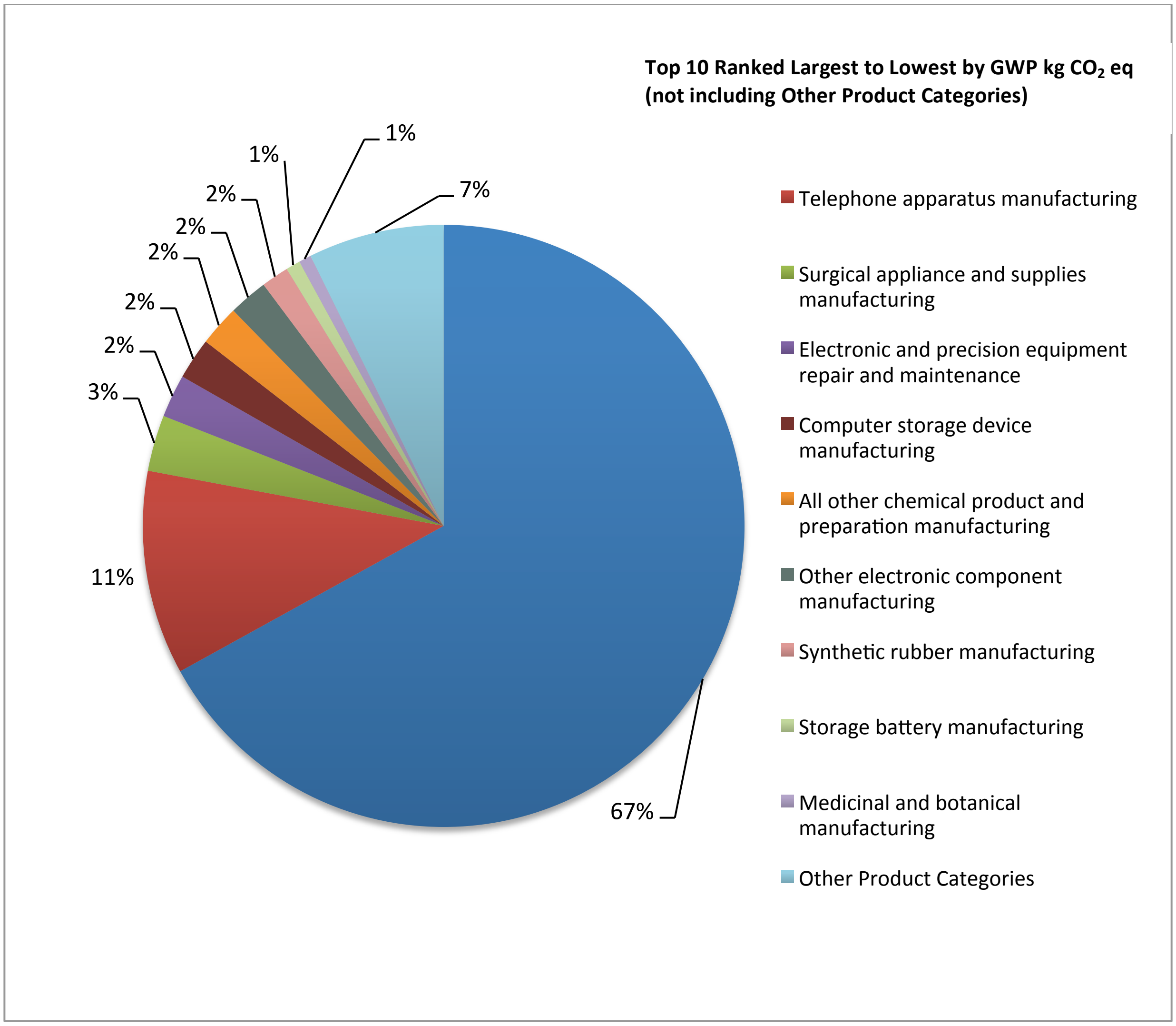

Figure 11: Department of Psychology & Brain Science Top 10 Product Categories for Global Warming Potential (in kg CO_2 equivalent)
For all 2011-12 transactions that totaled $60,684, the Department of Psychology & Brain Science had 44 product categories that were measured using CEDA for GWP. Overall these categories were found to emit 41,038 kg of CO_2 eq. through the production life cycle. Other Product Categories represent the sum of the remaining 34 product categories outside the top 10. Other Product Categories represent $7,009 in transactions and 2,995 kg of CO_2 eq.

Table 7: Department of Psychology & Brain Sciences Life Cycle Impact Assessment - Global Warming Potential					
IO Code	**IO Code Description**	**Impact Subtotals (kg CO2 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
541700	Scientific research and development services	252,576	$1,005,899	0.25	33%
334111	Electronic computer manufacturing	111,935	$101,151	1.11	15%
339111	Laboratory apparatus and furniture manufacturing	62,007	$224,554	0.28	8%
334516	Analytical laboratory instrument manufacturing	36,017	$129,569	0.28	5%
331110	Iron and steel mills and ferroalloy manufacturing	33,040	$13,725	2.41	4%
325211	Plastics material and resin manufacturing	26,322	$15,496	1.7	3%
325188	All other basic inorganic chemical manufacturing	24,430	$15,502	1.58	3%
5416A0	Environmental and other technical consulting services	23,636	$212,623	0.11	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	19,317	$33,296	0.58	3%
32619A	Other plastics product manufacturing	15,441	$18,730	0.82	2%
	Other product categories	161,694	$433,598	0.37	21%
TOTALS:		**766,415**	**$2,204,143**	**0.35**	**100%**

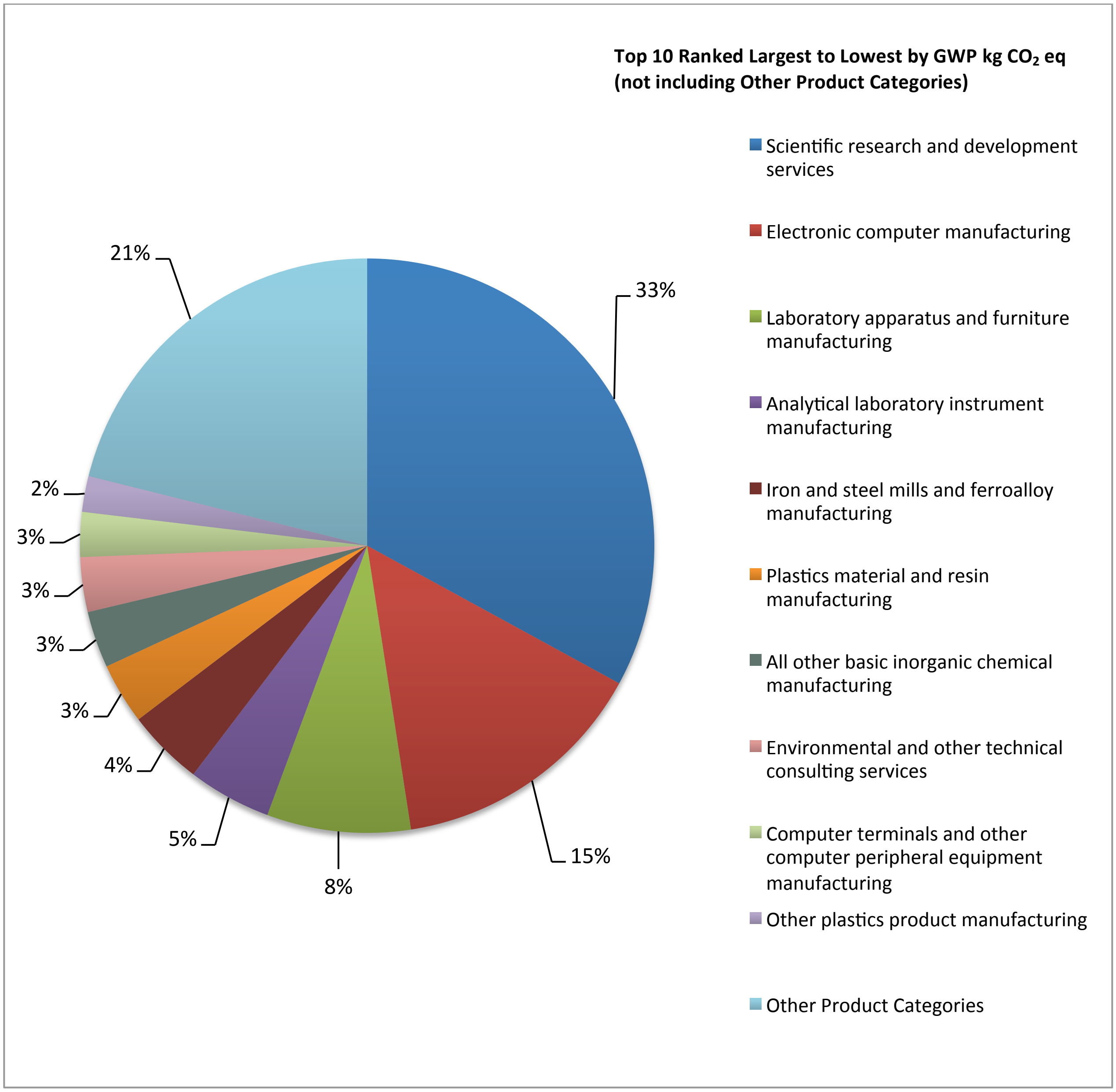

Figure 12: Earth Research Institute Top 10 Product Categories for Global Warming Potential (in kg CO_2 equivalent)
For all 2011-12 transactions that totaled $2,204,143, the Earth Research Institute had 154 product categories that were measured using CEDA for GWP. Overall these categories were found to emit 766,415 kg of CO_2 eq. through the production life cycle. Other Product Categories represent the sum of the remaining 144 product categories outside the top 10. Other Product Categories represent $433,598 in transactions and 161,694 kg of CO_2 eq.

Table 8: Earth Research Institute Life Cycle Impact Assessment - Global Warming Potential					
IO Code	**IO Code Description**	**Impact Subtotals (kg CO2 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
541700	Scientific research and development services	252,576	$1,005,899	0.25	33%
334111	Electronic computer manufacturing	111,935	$101,151	1.11	15%
339111	Laboratory apparatus and furniture manufacturing	62,007	$224,554	0.28	8%
334516	Analytical laboratory instrument manufacturing	36,017	$129,569	0.28	5%
331110	Iron and steel mills and ferroalloy manufacturing	33,040	$13,725	2.41	4%
325211	Plastics material and resin manufacturing	26,322	$15,496	1.7	3%
325188	All other basic inorganic chemical manufacturing	24,430	$15,502	1.58	3%
5416A0	Environmental and other technical consulting services	23,636	$212,623	0.11	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	19,317	$33,296	0.58	3%
32619A	Other plastics product manufacturing	15,441	$18,730	0.82	2%
	Other product categories	161,694	$433,598	0.37	21%
TOTALS:		**766,415**	**$2,204,143**	**0.35**	**100%**

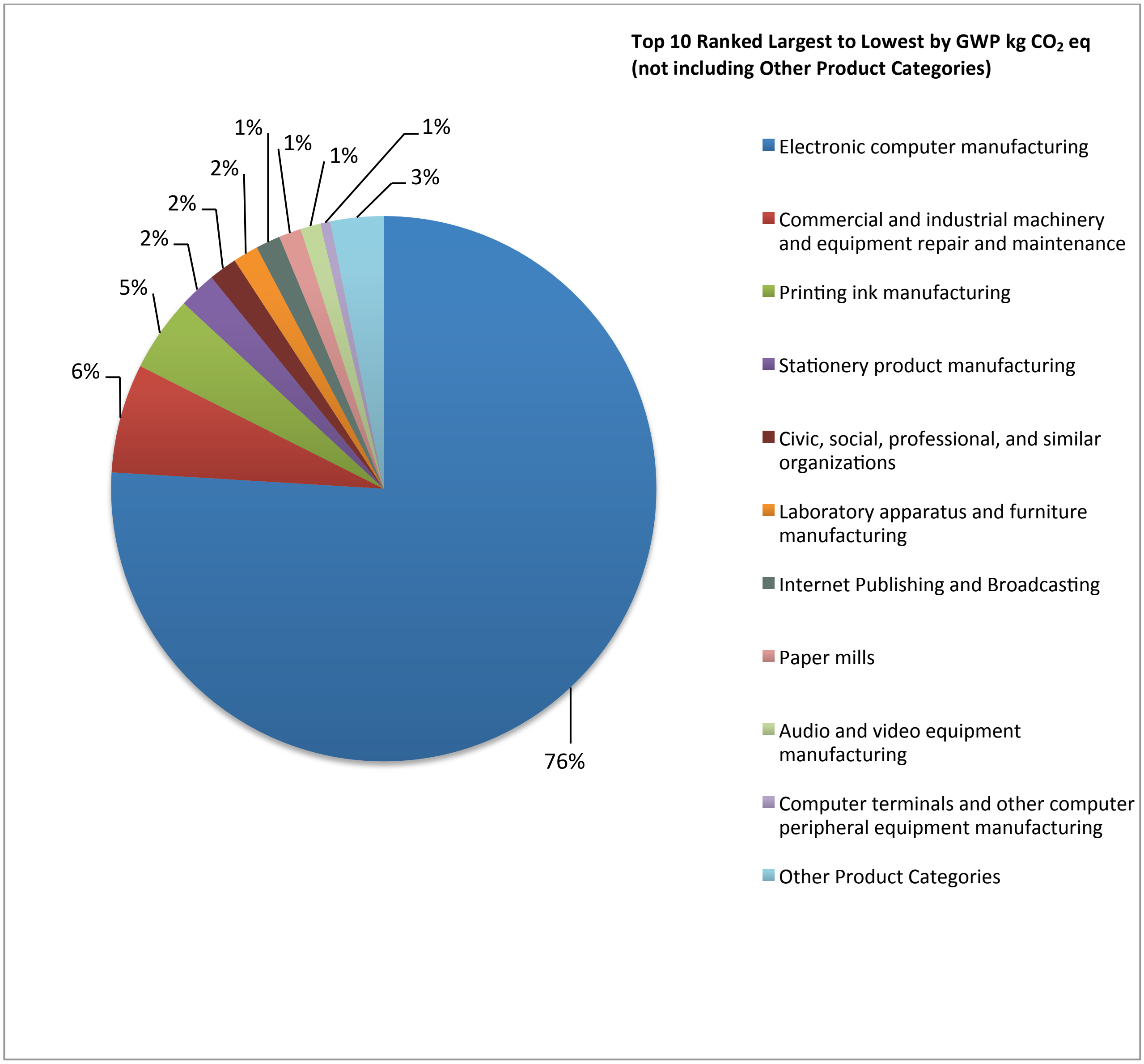

Figure 13: The Bren School of Environmental Science & Management Top 10 Product Categories for Global Warming Potential (in kg CO_2 equivalent) For all 2011-12 transactions that totaled $175,152 the Bren School had 32 product categories that were measured through CEDA for GWP. Overall these categories were found to emit 123,177 kg of CO_2 eq. through the production life cycle. Other Product Categories represent the sum of the remaining 22 product categories outside the top 10. Other Product Categories represent $11,348 in transactions and 3,884 kg of CO_2 eq.

Table 9: Bren School Life Cycle Impact Assessment - Global Warming Potential					
IO Code	**IO Code Description**	**Impact Subtotals (kg CO2 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	93,562	$84,548	1.11	76%
811300	Commercial and industrial machinery and equipment repair and maintenance	7,960	$43,286	0.18	6%
325910	Printing ink manufacturing	5,519	$5,840	0.95	4%
322230	Stationery product manufacturing	2,727	$4,420	0.62	2%
813B00	Civic, social, professional, and similar organizations	2,064	$6,950	0.3	2%
339111	Laboratory apparatus and furniture manufacturing	1,846	$6,684	0.28	2%
516110	Internet Publishing and Broadcasting	1,792	$7,490	0.24	1%
322120	Paper mills	1,630	$1,386	1.18	1%
334300	Audio and video equipment manufacturing	1,472	$1,960	0.75	1%
33411A	Computer terminals and other computer peripheral equipment manufacturing	720	$1,241	0.58	1%
	Other product categories	93,562	$84,548	1.11	76%
TOTALS:		**123,177**	**$175,152**	**0.7**	**100.00%**

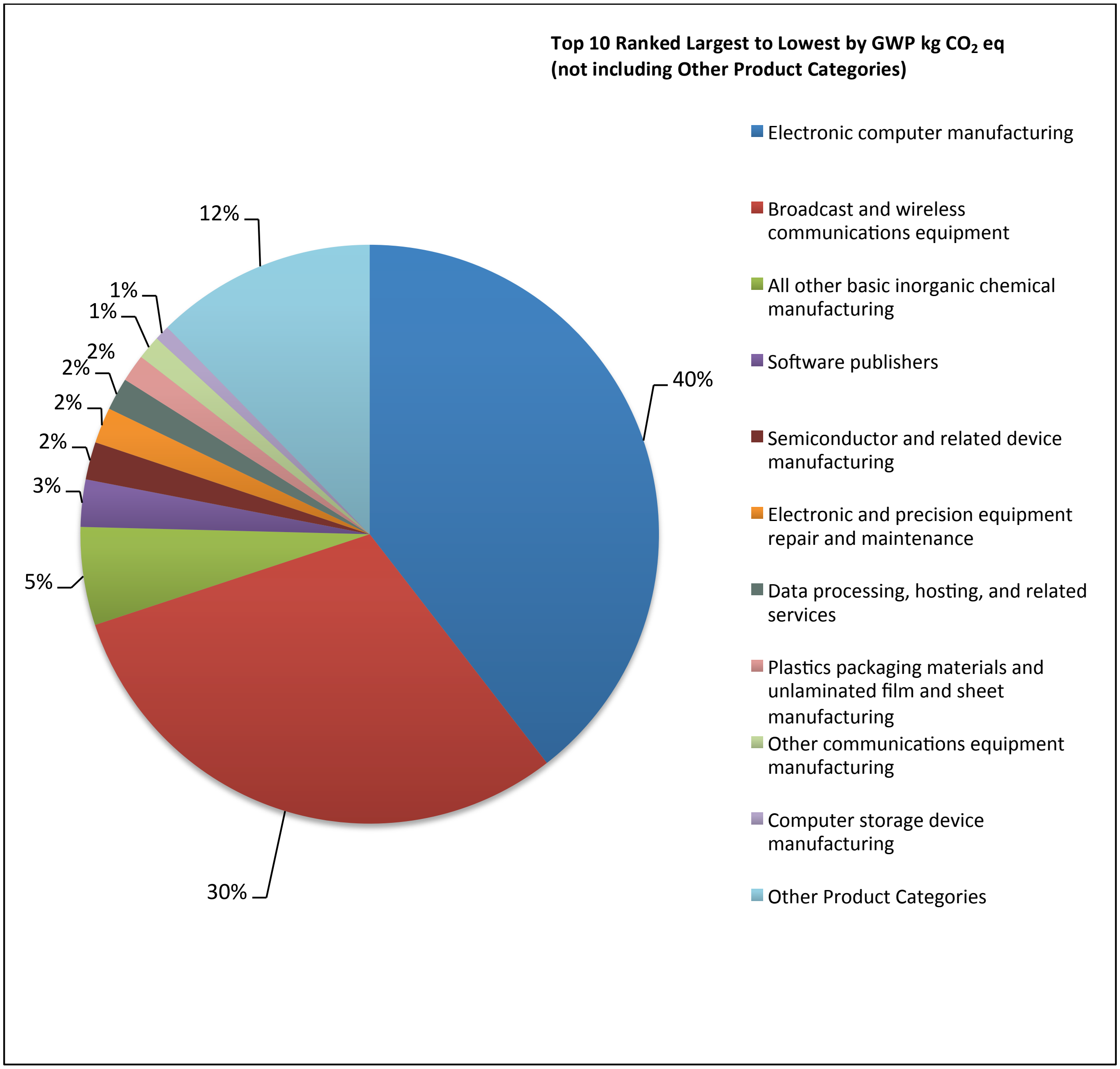

Figure 14: The Department of Geography Top 10 Product Categories for Global Warming Potential (in kg CO_2 equivalent)
For all 2011-12 transactions that totaled $568,284 the Department of Geography had 61 product categories that were measured using CEDA for GWP. Overall these categories were found to emit 252,083 kg of CO_2 eq. through the production life cycle. Other Product Categories represent the sum of the remaining 51 product categories outside the top 10. Other Product Categories represent $96,001 in transactions and 31,098 kg of CO_2 eq.

Table 10: Department of Geography Life Cycle Impact Assessment - Global Warming Potential					
IO Code	**IO Code Description**	**Impact Subtotals (kg CO2 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	99,589	$89,995	1.11	40%
334220	Broadcast and wireless communications equipment	76,681	$225,426	0.34	30%
325188	All other basic inorganic chemical manufacturing	13,808	$8,762	1.58	5%
511200	Software publishers	6,644	$58,473	0.11	3%
334413	Semiconductor and related device manufacturing	5,299	$5,581	0.95	2%
811200	Electronic and precision equipment repair and maintenance	5,039	$36,245	0.14	2%
518200	Data processing, hosting, and related services	4,585	$27,342	0.17	2%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	3,869	$4,122	0.94	2%
334290	Other communications equipment manufacturing	3,356	$10,646	0.32	1%
334112	Computer storage device manufacturing	2,114	$5,692	0.37	1%
	Other product categories	31,098	$96,001	0.32	12%
TOTALS:		**252,083**	**$568,284**	**0.32**	**100%**

CEDA AND CMU COMPARISON OF GWP RESULTS

By using the Carnegie Mellon University (CMU) model to assess the TRACI Impact Category of Global Warming Potential (GWP), for the same Input Output (IO) codes as CEDA, a direct comparison with CEDA results can be made. This comparison helps gauge the accuracy of the CEDA results across all the 183 product categories that were analyzed. While there were some differences between product categories, total results from the CMU model were only 2% less than those found using CEDA (Table 11). In the table below, sorted from product categories with the top 25 highest CEDA emissions, the differences between the CEDA and CMU results are highlighted. These differences show the variations between EIO methodologies, despite both models using TRACI impact characterization factors. Results for emissions from the paper mills category, for which the report goes into further detail, is only 3% greater from CEDA than the CMU model. A more complete comparison from CEDA and CMU results for all product categories is included in the Appendix.

Table 11: CEDA vs CMU Top 10 Product Categories for Global Warming Potential						
IO Code (CEDA)	**Product Category (CEDA)**	**CEDA Emissions Subtotals (kg CO_2e)**	**Percentage of Total Emissions (CEDA)**	**CMU Emissions Subtotals (kg CO_2e)**	**Percentage of Total Emissions (CMU)**	**Percentage Difference in Subtotals**
334111	Electronic computer manufacturing	332,573	18%	306,000	17%	-9%
541700	Scientific research and development services	252,576	14%	286,000	16%	12%
322291	Sanitary paper product manufacturing	235,987	13%	224,000	12%	-5%
322120	Paper mills	225,321	12%	218,000	12%	-3%
334220	Broadcast and wireless communications equipment	77,475	4%	72,000	4%	-8%
339111	Laboratory apparatus and furniture manufacturing	64,482	4%	60,700	3%	-6%
325610	Soap and cleaning compound manufacturing	63,841	3%	63,100	3%	-1%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	42,458	2%	39,200	2%	-8%
325188	All other basic inorganic chemical manufacturing	38,242	2%	27,600	2%	-39%
33411A	Computer terminals and other computer peripheral equipment manufacturing	37,981	2%	34,500	2%	-10%
	Other Product Categories	490,677	26%	497,998	27%	1%
TOTALS:		**1,861,614**	**100%**	**1,829,098**	**100%**	**-2%**

LIMITATIONS OF EIO-LCA

Though EIO-LCA is effective at estimating environmental impacts on an enterprise-wide scale, it has limitations particularly when compared with process-based LCA. CEDA, and all EIO-LCA models, rely on highly aggregated data compiled at the national level. This does not allow for detailed information regarding the practices of specific producers, and instead reduces the activity of all producers into one aggregated average value. For example, if UCSB were purchasing all of its sanitary paper from one company that had become environmentally conscious and used less energy than the typical sanitary paper company, this information would not be accurately reflected in the EIO-LCA results. This is where process-based LCA becomes more useful. Temporal limitations also exist because EIO-LCA does not take into account the fact that some environmental impacts become manifest years before or after the product has been manufactured (Suh, 2009).

Additionally, EIO-LCAs only represent cradle-to-gate impacts and do not consider transportation, use, or end of life phases. Despite the fact that many products have higher environmental impacts in stages following manufacturing, EIO-LCA does not include these impacts. However, since this project aims to understand the environmental effects of the purchase of products, which does not include use or disposal, EIO-LCA is still the most appropriate approach, especially when combined with other methods (Suh, 2009).

METHODOLOGY FOR COPY PAPER PROCESS-BASED LCA

While the EIO-LCA reflects the product categories with the greatest environmental impacts from cradle-to-gate, a process-based LCA (cradle-to-grave) method accounts for the use and end of life stages of the product. Results from both CEDA and CMU revealed paper mills to have one of the greatest contributions to GWP. This category was chosen for further analysis to determine whether paper reduction or substitution would have a greater environmental benefit. This analysis can be used as a framework for UCSB to conduct research for different product categories.

Environmental impacts result from various stages of paper's life cycle. The sourcing and collection stage includes fiber acquisition from either deforestation for virgin fiber or the collection and processing of recovered paper for recycled fiber. Deforestation impacts GHGs through land alteration, affecting carbon storage in both the soil and forest stock. Using recycled paper decreases the need for virgin fiber collection and processing, but also requires an increase in electricity during the production stage. Paper and pulp manufacturing requires fresh water, chemical and intensive energy use, and generates both hazardous air and water pollutants. Paper's use phase is not energy intensive relative to its other phases. Environmental impacts from paper waste management during the end of life stage include recycling, landfilling and incineration (The Paper Task Force, 1995).

A process-based LCA allows for comparison of paper at different recycled contents to determine which yields the greatest contribution to GWP over the course of its life cycle. Completing a process-based LCA was beyond the scope of this project given time and budgetary constraints; however both a literature review and utilization of the Environmental Paper Network's Paper Calculator compared the environmental impacts of paper reduction and substitution for low to high post-consumer recycled contents.

PAPER CALCULATOR

The Environmental Paper Network Paper Calculator is an online tool used to compare paper of different recycled contents using a process-based LCA approach. The Environmental Defense Fund (EDF) developed and operated the Paper Calculator from 2005 to 2011, then transferred ownership to the Environmental Paper Network. The tool allows for comparison across paper types, and is based on a study conducted by the EDF with input from the Paper Task Force, which consists of paper-purchasing stakeholders, such as major corporations and public institutions. The Paper Task Force completed a life cycle-based analysis for various grades of paper in a 28-month study, culminating in a report published in 1998 (Blum et al., 1997).

In 2005, the EDF developed an analytical model based on the findings of the Paper Task Force, and incorporated up-to-date industry data. In 2008, a third party examination of the tool by scientists and environmental NGOs included environmental impacts from paper's life cycle in the model, completed in 2009 as the Paper Calculator (Environmental Paper Network, 2011). The tool is reviewed and updated annually by the Environmental Paper Network with up to date scientific information (Porter, 2013).

The Paper Calculator uses publically available data when possible, as well as data from LCA consulting company, Franklin Associates. Data from Franklin Associates includes higher heating values (HHV), air and water emissions, solid waste, and total energy of all fuels in the model. These data are based on modules from the US Life Cycle Inventory Database, eGrid 2006 and GREET 1.8b. The Paper Calculator uses GWPs from the 2007 IPCC report (Franklin Associates, 2012).

PROCEDURE FOR PROCESS-BASED LCA USING PAPER CALCULATOR

The Paper Calculator was used to conduct a process-based LCA comparing paper at 0%, 30%, 50% and 100% post-consumer recycled content. Several paper categories can be compared; however, this study used the paper category "uncoated freesheet," as it included copy paper. Three mass-based options of functional units exist, including pounds of paper per year, which was used in this analysis. To determine environmental impact generated from copy paper purchased within the study sample from UCSB, total expenditure on copy paper for the year was converted into pounds per year. The total annual expenditure for copy paper was $179,092. The average unit price for copy paper was $5.31 and the average weight of a ream of paper was 20 pounds. Thus, the estimated total weight of copy paper for the year was 674,546 pounds. This number was entered into the Paper Calculator for recycled contents of 0%, 30%, 50%, and 100%, to generate environmental impacts for the following categories:

- Wood Use (tons)
- Net Energy (BTUs)
- Greenhouse Gases (pounds CO_2e)
- Water Consumption (gallons)
- Solid Waste (pounds)
- NO_x (pounds)

For the purpose of this project, GHG emissions were compared for paper at different recycled contents to correspond with the GWP analysis conducted with EIO-LCA. Environmental impact estimates were made using the Environmental Paper Network Paper Calculator Version 3.2.

RESULTS & DISCUSSION OF LCA USING PAPER CALCULATOR

GREENHOUSE GASES (GHGs)

The environmental impact of GHG emissions resulting from changing the recycled content of paper can be illustrated in terms of the number of pounds of CO_2eq./year for each quantity (Table 12). This reflects the environmental improvements in shifting to paper of higher recycled contents.

Table 12: # of Cars/Year at Different Recycled Contents				
Recycled Content	0%	30%	50%	100%
# Pounds CO_2 eq.	1,889,145	1,679,852	1,540,323	1,191,502

PAPER REDUCTION VERSUS SUBSTITUTION

Strategies to lessen the environmental impact of paper use at UCSB include reduction in usage and substitution for paper of higher recycled content. Reduction in paper usage yields environmental benefits at every stage of its life cycle, eliminating the need for harvesting, production, and disposal. While it was assumed that paper reduction would have a greater environmental impact than substitution, a comparison analysis was conducted to establish where the two would break even.

To compare the environmental impacts of reduction versus substitution, numbers were first generated for a 10% reduction in paper use at 30% recycled content and the effect on GHG emissions. Based on the survey results and the restriction of virgin paper on Gateway, it was assumed that most of the departments on campus already purchased paper of 30% post-consumer recycled content. This 10% paper reduction was calculated in both CEDA and with the Paper Calculator. Using CEDA, expenditure on copy paper was reduced by 10%, creating a 10% reduction in GWP. Running a 10% weight reduction per year in the Paper Calculator yielded the same 10% reduction in GHG emissions. The linearity of the two models generated the same 20% reductions in environmental impacts resulting from a 20% reduction in paper use.

To analyze the change in paper reduction versus substitution, these results were then compared with substituting paper of 30% post-consumer recycled content with higher recycled contents, increasing the recycled content by increments of 10% (Figure 16).

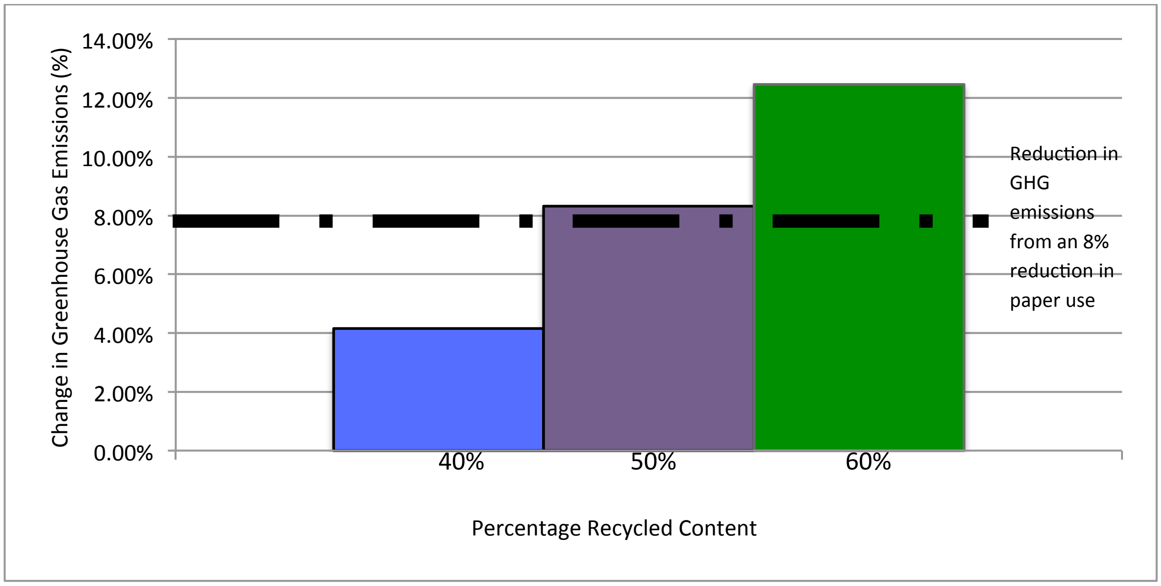

Figure 15: How changing paper use affects GHG emissions for reduction versus substitution

To achieve an 8% reduction in GHG emissions associated with paper reduction and substitution, copy paper would have to either be substituted to 50% post-consumer recycled content or reduced in use by 8%. This assumes a baseline of 30% post-consumer-recycled content. Both scenarios yield an 8% reduction in GHGs, which is where they break even.

Literature supports the finding of the importance of paper reduction. An EPA study reveals the carbon sequestration benefits of recycling versus reduction, given a baseline of current mixed virgin and recycled inputs. For office paper, source reduction increases the amount of sequestered carbon significantly more than recycling (USEPA, 2006). Paper reduction would not only improve UCSB's carbon footprint, but would also decrease financial costs, generating a win-win scenario for the campus (Geyer, et al., 2004).

While source reduction yields a greater environmental benefit, increasing recycled content lessens paper's overall environmental impact. It is recognized that eliminating all of paper usage on campus is not feasible, thus substituting with paper of higher recycled content is the best alternative.

Carbon sequestration is an aspect of paper's life cycle that is excluded from the Paper Calculator's calculations. Contradictory information exists regarding the fate of carbon in the soil when trees are harvested, and the model does not make assumptions about the possible gain or loss of carbon in the forest stock or the soil. The tool offsets this by assuming that carbon dioxide emitted from the landfill at the end of life stage is carbon neutral (Franklin Associates, 2012). It is possible that increasing the recycled content would then reduce GHG emissions more than is quantified by the Paper Calculator. Therefore, both paper source reduction and substituting for higher recycled contents would possibly yield greater GHG reductions than accounted for in this model.

A literature review of LCAs on virgin paper versus recycled content paper suggested recycling paper at the end of the life cycle has a lower environmental impact than landfilling or incineration when focusing on GHGs (Villaneuva et al., 2007; Grant et al., 2007; USEPA, 2006). This results largely from decreased methane emissions from paper decomposition in landfills. Incineration of paper utilizes energy from the methane, but still results in higher GHG emissions than recycling at the end of life phase. Another factor, which is included in some LCAs, results from higher carbon dioxide emissions from cutting virgin fiber for paper production. Research from one study found manufacturing processes for recycled paper required fewer resources and generated fewer pollutants than virgin paper (The Paper Task Force, 1995).

Based on both literature review and findings from paper sensitivity analyses, it is recommended that the first priority for reducing GWP from paper use on campus is to decrease consumption, and then substitute with higher recycled content. These tactics will reduce the campus' environmental impact in the targeted impact category, GWP.

This project assumed that paper reduction could be accomplished through double-sided printing and material reuse. It is also possible to reduce paper use by substituting with an alternative, such as using computers rather than printing or writing. In order to determine the impact on GHGs from material substitution, "the net GHG impacts of (1) source reduction of the original material, and (2) manufacture of the substitute material and its disposal fate" should be assessed (USEPA, 2006). Environmental tradeoffs exist and can factor into the decision-making process to provide a complete analysis, but were beyond the scope of this study.

LIMITATIONS OF PROCESSED-BASED LCA

Relative to EIO-LCA, process-based LCAs are costly and time intensive to conduct. Therefore, the use of this method was incredibly limited within the scope of this project. Additionally, there are limitations associated with process-based LCAs. One of the biggest is the need to set system boundaries. Because an LCA practitioner cannot realistically account for every single input and output within every phase of a product's life cycle, system boundaries must be determined. This limits the processes that can be included in an LCA, and therefore completeness, and is highly subjective (Hendrickson et al, 2006).

Process LCAs are also typically proprietary, making them difficult and expensive to obtain. This also means they may not be replicated if confidential information is used. Additionally, because process-based LCAs are typically designed to measure specific product systems, they may be difficult or impossible to apply to a different process design, requiring a new process design be created from the ground up for each product analyzed, further increasing cost and time requirements (Hendrickson et al, 2006).

LCA CONCLUSIONS

An EIO-LCA is a top-down approach to LCA, which allows for pinpointing of products with the greatest room for environmental improvement. This method will allow the campus to make targeted recommendations for sustainable purchasing. Identification of the product categories with the greatest environmental impacts both across campus and within departments validates sustainability recommendations for those categories.

The EIO-LCA conducted in this project revealed the differences between departmental expenditures and subsequent environmental impacts. 56% of the total GWP came from four product categories: electronic computer manufacturing, scientific research and development services, sanitary paper product manufacturing, and paper mills, and was dispersed across the sampled departments. Central Stores constituted the largest percentage of expenditure on paper products, while Earth Research Institute and the Department of Psychology & Brain Sciences purchases were related to scientific research and laboratory equipment. The Bren School's purchases were mostly computer related and the Geography Department largely included computers and other wireless communication devices. It is important to consider both the overall campus and the differences in departments in order to make recommendations for sustainable purchasing.

Once the EIO-LCA identifies the product categories with the greatest environmental impacts, various techniques exist to improve those product categories. Among these techniques, process-based LCA is the preferred methodology. However, performing a complete process-based LCA is not always feasible, and referencing literature and other LCA models, such as the Paper Calculator, for comparison can help provide a clearer picture of the full cradle-to-grave impacts. These techniques can help to further analyze opportunities for environmental improvement, such as substitution or reduction.

This project analyzed copy paper using the Paper Calculator, determining that a reduction in paper use had a greater environmental benefit than increasing the recycled content. Campus-wide, an increase to 50% post-consumer recycled content paper would break even with an 8% reduction in overall paper use.

However, it should be kept in mind that when a product's purchase is reduced or substituted, tradeoffs in environmental impacts might be introduced. This is especially true in cases of product substitution. For example, reducing paper may increase computer usage. While outside the scope of this project, a full analysis should explore environmental tradeoffs. Such tradeoffs will vary across product categories, and changes in net emissions should be examined.

While the scope of this analysis only constituted about 5% of total campus expenditures, the framework developed can be utilized for a broader campus study and in the determination of a baseline of environmental impacts. UCSB can then target relevant impact categories and develop measureable goals for success. It can focus on the areas that need further progress and recognize those departments making environmental improvements.

SURVEY OF UCSB PURCHASING BEHAVIOR

BACKGROUND

A survey was administered across campus to understand purchasing behavior at UCSB. The shift to Gateway is changing campus purchasing, creating an opportunity to influence behavior toward more sustainable products. It was assumed that campus purchasers considered sustainability when choosing products, but did not always know where to find them, especially using the new system. The purpose of the survey was to determine the attitudes, behaviors, opportunities and barriers in regards to sustainable purchasing. Basic information sought from the survey included identification of purchasers and purchasing practices as they relate to environmentally preferable products. This phase of the framework allows for the development of strategies to encourage sustainable purchases in Gateway.

SURVEY METHODOLOGY

After creating questions and corresponding hypotheses, attaining feedback, and having all team members take and pass the human subjects exam, the survey was distributed to the purchasing and accounting listservs on November 13, 2012, reaching 482 people. These listservs targeted members of campus who subscribe to email updates from either the purchasing or the accounting departments to best understand UCSB's purchasing behavior. Upon receipt of the email, respondents could access the survey online via SurveyMonkey. Completion of the survey was voluntary, and responses were incentivized with a $50 Visa Gift Card. The initial e-mail was then followed up with a reminder on November 20, 2012. On December 12, 2012, the winner of the $50 Visa Gift Card was determined at random.

The survey, shown in the Appendix 5, included twenty-one questions.

SURVEY RESULTS

Of the 482 campus employees who received the survey, 156 (32%) completed it. It was asked if the respondent purchased for his/her department, 100 (64%) of whom did, and the remainder were directed to the "exit page" of the survey.

Of the respondents who reported making purchases for their department, their current positions included: Accountant Assistant (1), Administrative Assistant/Coordinator/Manager (12), Analyst (11), Assistant (2), Budget Analyst (1), Business Officer/Manager (12), Buyer (1), Contracts and Grants Manager (2), Corporate Programs Manager (1) Director (6), Financial Analyst (3), Financial Assistant (6), Graduate Student/Teaching Assistant (3), Manager (3), Office Manager (5), Purchasing Analyst/Agent (3), and Travel Manager (1). The respondents who did not purchase for their departments and were then directed to the exit page had similar job titles.

Respondents worked in administrative, science, and social science and humanities departments. Administrative departments included: Academic Senate, Accounting, Athletics, Business and Financial Services, the Chancellor's Office, Campus Learning Assistive Services, the Disabled Students Program, Environmental Health and Safety, Facilities Management, Housing and Residential Services, Instructional Development, the Library, Purchasing, Student Health, and Transportation and Parking Services. A total of 12 Social Science and Humanities departments were represented, including: Anthropology, Communication, Education, Global Studies, Sustainability, and Theatre and Dance. Finally, the Science departments included: Bren School, Chemical Engineering, Earth Research Institute, Geography, Materials Research, Military Science, and

Psychology and Brain Sciences. Unless noted, no more than 2 employees from each of these departments completed a survey, making bias based on department unlikely.

The array of respondent job titles and departments shows the diffusion of departmental purchasers, increasing the likelihood that a representative sample of campus purchasers completed the survey.

Question 5 asked, "What types of products do you purchase?" 97 respondents answered, and many selected at least 5 of the product categories. Some reported purchasing only one, and some all 10 (data in Table 20). The most frequent product-type purchased was pens, pencils and general office supplies (76 respondents, 78%). Over 50% of respondents purchased the following products: paper products (74%), ink/toner (74%), computers (72%), batteries (67%), and large appliances (62%). The least frequently purchased products were lab supplies and lab equipment (25% and 23% respectively). As hypothesized, a wide range of products is purchased on campus. Write-in responses broadened this range to include food products, furniture, clothing, software, and various types of specialized equipment.

Table 20: Number and percentage of respondents purchasing specific product types

Product Type	Number of Respondents	Percentage
Pens, Pencils, General Office Supplies	76	78%
Paper Products	72	74%
Ink/Toner	72	74%
Computers	70	72%
Batteries	65	67%
Larger Appliances	60	62%
Cleaning Supplies	46	47%
Dining Items	38	39%
Lab Supplies	24	25%
Lab Equipment	22	23%

The definition of "sustainability" is often unclear, and the meaning of the term was vital for the responses to several questions, so a definition was provided to "define a sustainable product as having a lower environmental impact than a typical or standard product with the same function."

Question 6 asked, "What proportion (by dollar amount) of the total purchases you make on campus are sustainable products?" The purpose of this question was to determine whether or not purchasers believe they are choosing sustainable options when they make purchases. It was found that less than 50% of respondents' purchases were considered sustainable (Table 21). However, of 95 respondents, over 30% reported they did not know what proportion of their purchases was sustainable. This suggests that there is an opportunity to increase the level of sustainable purchasing on campus, but also that better information about products and campus goals are needed.

Table 21: The proportion of total purchases reported as sustainable by number and percentage of respondents

Proportion of total purchases reported as sustainable	Number of Respondents	Percentage
0-24%	17	18%
25-49%	22	23%
50-74%	20	21%
75-99%	6	6%
100%	0	0%
Don't know	30	32%

Question 7 asked, "Does your department refer to sustainable purchasing guidelines?" UCSB has several sustainable purchasing guidelines for specific departments, and it is a UC sustainability goal to increase sustainable purchasing at all levels. It was hypothesized that department purchasers are referring to these guidelines, and 60% of respondents said that they did. 34% were unsure if they had sustainable purchasing guidelines and only 6% reported that their departments did not refer to such guidelines. This confirmed that sustainable purchasing guidelines are being referenced, but in conjunction with the previous question it does not appear that the guidelines are effective at helping employees make sustainable purchases. These responses point out the need for sustainable purchasing guidelines to be widely distributed and clearly explained.

Questions 8-10 included the following:

- Does the sustainability of a product affect your decision to buy it?
- How does the sustainability of a product affect your decision to purchase it?
- Do you have the authority to purchase sustainable products rather than the lower cost or * more frequently selected product?

Questions 8-10 showed that most respondents believe that they are personally thinking about a product's sustainability, are more likely to purchase a sustainable product, and also have the authority to purchase sustainable products. Despite the fact that a low proportion of products currently purchased on campus are reported as sustainable, the employees making purchases reported a product's sustainability as having an effect on their decision to buy it. 81% of respondents (78 respondents) reported that their decisions about purchasing are affected by a product's sustainability. 96% of these respondents said that a product's level of sustainability made them more likely to purchase it.

If the respondents did not believe that they had the authority to choose sustainable products, this would help to explain the low proportion of sustainable products being purchased. However, 60% of respondents did report having such authority, only 16% reported that they were certain that they did not, and 24% were uncertain. Those who responded that they did not have the authority to make sustainable purchases reported that they could make recommendations, that the person ordering the product or a supervisor had the authority or that budgetary restrictions limited their authority.

To increase sustainable purchasing on campus, campus purchasers (whether that be the person completing the order online or the person requesting the purchase) should have the authority to select sustainable products when they are available. Respondents appear to have a preference for purchasing sustainable products, and making them easy to find will likely increase the proportion of sustainable purchases.

Questions 11-12 asked:

- Does your office purchase recycled copy paper?
- What percentage recycled paper content is it?

Questions 11 and 12 strictly regarded the paper used in respondents' offices or departments. UCSB policy restricts the purchase of virgin paper, and the Gateway purchasing system was recently updated to require special permission for the purchase of virgin paper. Anecdotal evidence from other universities' Green Office Programs suggested that recycled paper content above 30% is frequently viewed as inferior in quality, causing paper jams. It was hypothesized that most offices used recycled content paper, with 30% post-consumer recycled content as the most common.

Nearly 90% of respondents reported that their office purchases recycled paper and the most common recycled content was 30% (Table 22). Two respondents reported that their offices did not purchase recycled paper because of paper jams.

Table 22: The level of recycled content in paper being purchased by respondents and/or their departments

Recycled Content	Number of Respondents	Percentage
30%	37	40%
50%	19	21%
100%	16	17%
Unsure	20	22%

There are greater environmental benefits from paper reduction than from increasing the recycled content, as discussed in the paper section analysis. However, if samples of 50% and 100% recycled content paper are provided to offices currently using 30% recycled paper, it is highly likely that they will not see a change in the quality of the paper and will be willing to purchase the more sustainable paper.

Questions 13-15 asked the respondent to think of the last time he/she purchased a sustainable product.

Question 13 asked, "What product type was it?" The most frequently reported category was paper products, by a large margin (Table 23). Office supplies and inks and toners were the most common responses after paper, but were only a small percentage of the responses.

Table 23: Product types reported to be the last product type that the respondent chose a sustainable option when purchasing.

Product Type	Number of Respondents	Percentage
Paper	51	61%
Office Supplies	11	13%
Ink/toner	7	8%
Dining Items	6	7%
Cleaning Supplies	4	5%
Computers	3	4%
Batteries	1	1%
Lab Equip.	1	1%
Lab Supplies	0	0%
Larger Appliances	0	0%

Question 14 asked, "Was this option more expensive than the non-sustainable option?" 58% of respondents stated that the last sustainable product they purchased was about the same price as the non-sustainable option, 31% stated that it was more expensive, and only 11% stated that it was less expensive.

The fact that purchasers reported spending more money on a sustainable option signifies that if sustainable options are available, budgets already provide some allowance for such choices. However, the fact that 58% of respondents did not spend more on the sustainable option does confirm that price equality makes sustainable products easier to purchase.

Question 15 asked, "How was the quality?" 87% of respondents reported that the sustainable product quality was equal to the average/non-sustainable product quality, suggesting that experiences with sustainable products have been positive and that paper jams are less problematic than perceived. Only 2% reported that the sustainable product they last purchased was of worse quality than average.

An important product that was not selected was "batteries". One respondent wrote that he saw rechargeable battery options as an opportunity to improve sustainability in purchasing. If offices are provided educational information for rechargeable batteries and encouraged to use them with Gateway, it could reduce the environmental impact of batteries used on campus (Watson, 2007).

Questions 16 and 17 asked the respondent to think of the last time he/she purchased a non-sustainable product.

Question 16 asked what product type the non-sustainable product was. The most frequently reported was paper, followed by general office supplies (Table 24). This is an unexpected result, since it is unlikely that virgin paper was being purchased.

The question specifically asked about the last non-sustainable product purchased, which could be correlated with frequently purchased products. Frequent purchases affected both the most recent sustainable item purchased and most recent non-sustainable item purchased. However, the fact that some respondents' non-sustainable products were other respondents' sustainable products reveals the need for widespread education for all product types.

Table 24: Product types reported to be the last product type that the respondent did not choose a sustainable option when purchasing

Product Type	Number of Respondents	Percentage
Paper Products	14	17%
Pens, Pencils, General Office Supplies	13	16%
Cleaning Supplies	13	16%
Ink/Toner	10	12%
Dining Items	8	10%
Other	7	9%
Batteries	5	6%
Computers	3	4%
Lab Equipment	3	4%
Larger Appliances	3	4%
Lab Supplies	3	4%

Question 17 asked, "Why did you choose not to purchase the product (or sustainable version of the product?" The most common reason was that the purchaser did not know where to find a sustainable option. Price and uncertainty about performance were the next two most common issues (Table 25).

Table 25: Reasons sustainable products were not purchased by survey respondents

Response	Number of Respondents	Percentage
Didn't know where to find a sustainable option	26	33%
Price	15	19%
Uncertainty about the product's performance	14	18%
Other	13	16%
Required to purchase specific (non-sustainable) product	13	16%
Quality	11	14%
Prefer something else	3	4%
Don't trust environmental/sustainability labels	0	0%

Cost and availability of sustainable options should be addressed to increase sustainable purchasing on campus. Write-in responses included not having time to research a sustainable option and not having the authority to make the sustainable choice. The fact that price was not the top issue suggests that Gateway can have a substantial impact on what level of sustainability exists in product choice if the system provides sustainable options that are easily accessible.

Question 18 asked, "In general, are there specific product brand or types that you always choose?" 43% said that they did, while 57% said that they did not. The results for this question provide evidence that if a sustainable option is presented in Gateway at a competitive price, brand name may not create a barrier.

Question 19 asked, "What factors do you consider when purchasing products for your department?" The factor with the highest average ranking was option availability. Convenience, specific product requirement, and standard choice were also highly ranked, while cost and quality were not frequently ranked very high (Table 26).

Table 26: Overall ranking of factors considered when purchasing products

Overall Rank	Factor
1	It is the only option available
2	Required to use specific product
3	We always buy this product/standard choice
4	Convenience
5	Sustainability
6	Cost
7	Quality

Question 20 asked, "What do you think is the greatest opportunity to improve the sustainability of purchasing in your office?" For this question, respondents were asked to write in their own ideas. The most common responses included increasing awareness, information, and availability. One respondent suggested a weighting system of sustainable products in the new purchasing system and another recommended reaching out to faculty to convince them that sustainability should be an important criteria in their purchasing decisions.

Question 21 asked, "Do you know where in your building or on campus to take batteries, ink cartridges, toner cartridges and other electronic waste?" Almost all respondents (98%) said yes. It can be inferred that focusing on purchasing is a much more important issue, since UCSB has already taken great strides to ensure safe disposal of electronic waste.

COMPARISONS ACROSS DEPARTMENTS

A slightly higher percentage of respondents from the humanities departments reported purchasing ink and toner than the administrative departments and science departments (Fig. 17). There are more respondents in the science departments purchasing computers. Otherwise, there is not a great deal of variation across the departments within each category.

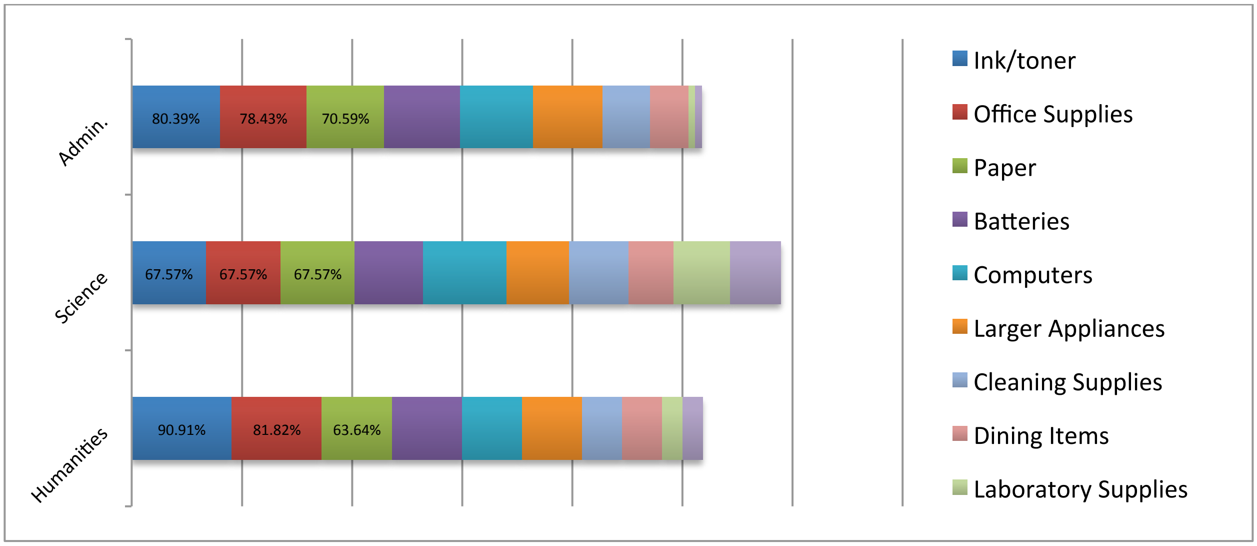

Figure 16: Separation of product types being purchased most frequently based on type of department or office

In each department type there were a similar number of respondents who did not know what proportion of their purchases were sustainable. In the administrative departments, respondents felt more certain that they were buying 50-74% sustainable products, the highest average level of sustainability reported across the three department types. The administrative departments also had the highest percentage of respondents reporting that they were aware of the sustainability of their purchases, suggesting they are less in need of sustainability education. Of all of the departments, the administrative department has the fewest people who reported only 0-24% of their purchases as sustainable. Nonetheless, since the administrative departments purchase more office supplies than other departments, it may be easier for them to track sustainability and choose sustainable options.

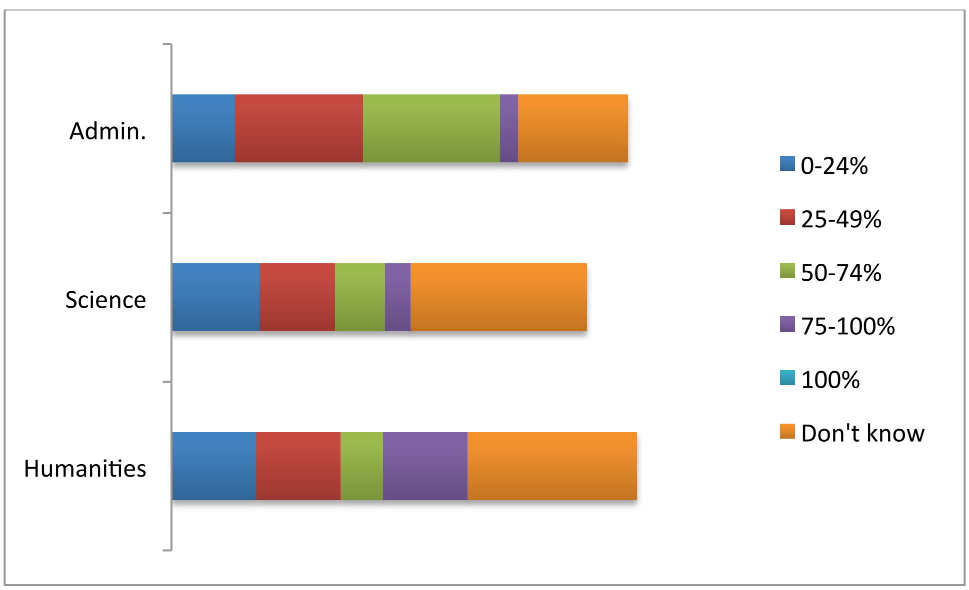

Figure 17: Percentage of purchases reported to be sustainable for each department/office type

HIGHLIGHTED RESULTS AND RECOMMENDATIONS FROM SURVEY

Recommendations elicited from survey responses include defining sustainable products and making them visible on Gateway. In addition, sustainable purchasing guidelines should be widely distributed. Educating buyers about campus EPP goals and methods of achieving them would incentivize buyers to purchase sustainable products. The survey results also reveal the opportunity to increase the recycled content of paper from 30%, since it is being purchased most widely. The campus thus has the ability to decrease the GWP of paper mills by increasing expenditures on higher recycled content paper.

Another recommendation from survey findings relates to environmental certifications. Purchasers buy sustainable products when they are easily accessible, and Gateway's framework allows for UCSB favorites to rise to the top of the search. Because a process-based LCA is not always feasible, a technique on Gateway could promote products with certain environmental attributes. Third party certifications supported by UCSB include EPEAT and ENERGY STAR. First-party certifications are vendor verified, and include green flags by companies like Office Max. A ranking system in Gateway where the third party-certifications rise to the top of the UCSB favorite basket, followed by first-party verified products, and finally the rest of the products, would incentivize the purchase of targeted environmental products. After this tactic is enacted, the procurement office should send a follow-up survey and monitor Gateway expenditures to see how purchasing behavior changes.

SURVEY LIMITATIONS

The results of the survey were dependent upon who responded and despite the fact that many people on campus are making purchases only those people on the Accounting or Purchasing listservs were given the opportunity to fill out the survey. There was no requirement for completing the survey, so the respondents had to be interested in the survey and/or its missions, or feel some level of obligation to respond. This may have created a bias toward respondents who are interested in sustainability in purchasing, therefore increasing the likelihood that they would report making or wanting to make sustainable purchases.

The results from the survey are also dependent on the respondents' understanding and bias towards survey questions. Interpretation and favoritism can lead to misinformation that can limit the effectiveness of the survey in improving purchasing processes. For example, one question asked the respondent to identify the last non-sustainable product he/she purchased. Despite the fact that a high percentage of respondents reported that they purchased 30% (or greater) recycled content paper, paper was identified as a non-sustainable product that was frequently purchased last. It is likely that there was a lack of certainty regarding how high the recycled content would have to be for paper to be considered sustainable.

FINAL RECOMMENDATIONS

The implementation of Gateway is a critical first step in tracking and monitoring purchasing at UCSB. In addition, we recommend using Gateway in conjunction with the project framework in order to improve the sustainability of the campus' supply chain.

Several key components of this framework include:

- A product coding system within Gateway that allows for individual product purchases to be tracked.
- Aligning Gateway with an EIO-LCA model to provide an analysis of the environmental impact of purchases made campus-wide. Analyzing expenditures in this manner will provide the Purchasing Department the ability to identify departments and products with high environmental impacts. This will also help determine a baseline of environmental performance and set measurable targets for improvements. The University can also determine and appropriately weight the environmental impact categories it seeks to analyze.
- Using the EIO-LCA results to further examine products with high environmental impacts through the use of process LCA. Though time and cost intensive, this option may at least be considered for detailed measuring of impacts at the individual product-level to determine whether restriction or reduction of use, or substitution for environmentally friendly options is the best alternative. Environmental tradeoffs can also be assessed with process-LCA.
- Surveying purchasers across all campus departments to understand behavior and attitudes in regards to sustainable purchasing. This type of analysis may be conducted less often, such as every few years.
- Creating an EPP list from the EIO-LCA, process LCA, and survey results. Integrating information obtained from the survey with the implementation of EPPs will help to optimize the use of Gateway.

Other strategies within Gateway include:

- Creating reports for specific departments and specific product categories or flags to determine the level of sustainable purchases being made and to illustrate how these levels change over time.
- Restricting high impact products.
- Tracking purchases to empower UCSB to leverage its purchasing power with suppliers. UCSB may be able to use the information gained regarding the volume of its purchases as well as varying environmental impact to pressure suppliers to provide more environmentally sound products at prices more favorable to UCSB. This will also encourage vendors to attain more transparency in the supply chain.

Final recommendations to the Purchasing Department include:

- Using information from conducting LCAs to increase transparency, both at the campus level and with UCOP. Results may be provided to the Chancellors sustainability committee in order to apply for recognition for rankings listings such as Sierra Club's top environmental schools. This could help the campus capitalize on sustainability efforts by attracting top talent – both students and instructors.

- Sharing the results of EIO-LCA with department purchasers to communicate the impact their purchases have. This may initiate a sense of accountability and if the results can be shared openly across campus, may initiate competition among departments to improve their environmental performance.

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APPENDIX

Appendix 1: LCA Modeling at Midpoint Versus Endpoint Level

Table 27: Cause-Effect Chain Selection for TRACI			
Impact Category	**Midpoint level selected (TRACI)**	**Level of site specificity selected**	**Possible endpoints**
Global Warming	Potential global warming based on chemical's radiative forcing and lifetime	Global	Malaria, coastal area damage, agricultural effects, forest damage, plant and animal effects
Acidification	Potential to cause wet or dry acid deposition	U.S., east or west of the Mississippi River, U.S. census regions, states	Plant, animal, and ecosystem effects, damage to buildings
Eutrophication	Potential to cause eutrophication	U.S., east or west of the Mississippi River, U.S. census regions, states	Plant, animal and ecosystem effects, odors and recreational effects, human health impacts
Photochemical smog	Potential to cause photochemical smog	U.S., east or west of the Mississippi River, U.S. census regions, state	Human mortality, asthma effects, plant effects
Ecotoxicity	Potential of a chemical released into an evaluative environment to cause ecological harm	U.S.	Plant, animal, and ecosystem effects
Human Health: criteria air pollutants	Exposure to elevated particulate matter less than 2.5lm	U.S., east or west of the Mississippi River, U.S. census regions, states	Disability-adjusted life-years (DALYs), toxicological human health effects
Human health: cancer	Potential of a chemical released into an evaluative environment to cause human cancer effects	U.S.	Variety of specific human cancer effects
Human health: noncancer	Potential of a chemical released into an evaluative environment to cause human noncancer effects	U.S.	Variety of specific human toxicological noncancer effects
Fossil fuel	Potential to lead to the reduction of the availability of low cost/energy fossil fuel supplies	Global	Fossil fuel shortages leading to use of other energy sources, which may lead to other environmental or economic effects
Land use	Proxy indicator expressing potential damage to threatened and endangered species	U.S., east or west of the Mississippi River, U.S. census regions, state, county	Effects on threatened and endangered species (as defined by proxy indicator)
Water use	Not characterized at this time		Water shortages leading to agricultural, human, plant, and animal effects

Source: Bare et al. (2003)

Appendix 2: CEDA Results – Top 10 Product Categories For All Environmental Impact Categories

Top 10 Product Categories Ranked by Contribution to Global Warming Potential

IO CODE	Product Category	Environmental Impact (kg CO2 eq)	Dollar Amount Spent	Environmental Impact per Dollar (kg CO2 eq/$)	Percent of Total GWP Emissions
334111	Electronic computer manufacturing	332,573.480	$300,532.02	1.1066	17.9
541700	Scientific research and development services	252,576.189	$1,005,899.08	0.2511	13.6
322291	Sanitary paper product manufacturing	235,986.738	$261,369.47	0.9029	12.7
322120	Paper mills	225,321.386	$191,641.63	1.1757	12.1
334220	Broadcast and wireless communications equipment	77,475.390	$227,761.90	0.3402	4.2
339111	Laboratory apparatus and furniture manufacturing	64,481.989	$233,517.85	0.2761	3.5
325610	Soap and cleaning compound manufacturing	63,840.603	$99,377.91	0.6424	3.4
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	42,458.027	$45,233.76	0.9386	2.3
325188	All other basic inorganic chemical manufacturing	38,242.214	$24,266.85	1.5759	2.1
33411A	Computer terminals and other computer peripheral equipment manufacturing	37,981.180	$65,467.33	0.5802	2.0

Top 10 Product Categories Ranked by Contribution to Water Consumption

IO CODE	Product Category	Environmental Impact (kg)	Dollar Amount Spent	Total Environmental Impact per Dollar (kg/$)	Percent of Total Water Consumption
334111	Electronic computer manufacturing	24,552,928.653	$300,532.02	81.6982119	21.7
541700	Scientific research and development services	17,924,511.512	$1,005,899.08	17.81939348	15.8
322291	Sanitary paper product manufacturing	13,044,779.325	$261,369.47	49.90934605	11.5
322120	Paper mills	11,710,085.261	$191,641.63	61.1040788	10.4
334220	Broadcast and wireless communications equipment	5,676,545.636	$227,761.90	24.92315719	5.0
339111	Laboratory apparatus and furniture manufacturing	4,370,553.929	$233,517.85	18.71614495	3.9
325610	Soap and cleaning compound manufacturing	3,205,660.668	$99,377.91	32.25727597	2.8
334516	Analytical laboratory instrument manufacturing	2,560,266.630	$133,779.37	19.13797793	2.3
33411A	Computer terminals and other computer peripheral equipment manufacturing	2,419,359.195	$65,467.33	36.95521407	2.1
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	1,880,259.392	$45,233.76	41.56761215	1.7

Top 10 Product Categories Ranked by Primary Energy Consumption

IO CODE	Product Category	Total Environmental Impact (Direct & Indirect Inputs) (thousand BTU)	Dollar Amount Spent	Total Environmental Impact per Dollar (thousand BTU/$)	Percent of Total Energy Consumption
541700	Scientific research and development services	2,017,174.496	$1,005,899.08	2.0053	17.2
334111	Electronic computer manufacturing	1,945,174.005	$300,532.02	6.4724	16.6
322291	Sanitary paper product manufacturing	1,411,226.424	$261,369.47	5.3994	12.0
322120	Paper mills	1,350,292.175	$191,641.63	7.0459	11.5
492000	Couriers and messengers	511,039.489	$44,852.06	11.3939	4.4
325610	Soap and cleaning compound manufacturing	473,286.751	$99,377.91	4.7625	4.0
334220	Broadcast and wireless communications equipment	436,700.384	$227,761.90	1.9174	3.7
339111	Laboratory apparatus and furniture manufacturing	359,430.676	$233,517.85	1.5392	3.1
33411A	Computer terminals and other computer peripheral equipment manufacturing	236,291.246	$65,467.33	3.6093	2.0
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	213,001.472	$45,233.76	4.7089	1.8

Top 10 Product Categories Ranked by Acidification					
IO CODE	Product Category	Total Environmental Impact (Direct & Indirect Inputs) (H+ moles eq)	Dollar Amount Spent	Total Environmental Impact per Dollar (thousand BTU/$)	Percent of Total H+ Emissions
322291	Sanitary paper product manufacturing	101,660.254	$261,369.47	0.3890	17.5
322120	Paper mills	96,761.045	$191,641.63	0.5049	16.7
541700	Scientific research and development services	91,951.809	$1,005,899.08	0.0914	15.8
334111	Electronic computer manufacturing	85,645.639	$300,532.02	0.2850	14.8
334220	Broadcast and wireless communications equipment	20,443.232	$227,761.90	0.0898	3.5
339111	Laboratory apparatus and furniture manufacturing	15,177.164	$233,517.85	0.0650	2.6
325610	Soap and cleaning compound manufacturing	14,820.132	$99,377.91	0.1491	2.6
3259A0	All other chemical product and preparation manufacturing	9,410.699	$37,592.43	0.2503	1.6
334516	Analytical laboratory instrument manufacturing	9,242.440	$133,779.37	0.0691	1.6
33411A	Computer terminals and other computer peripheral equipment manufacturing	9,182.105	$65,467.33	0.1403	1.6

Top 10 Product Categories Ranked by Eutrophication					
IO CODE	Product Category	Environmental Impact (kg N eq)	Dollar Amount Spent	Environmental Impact per Dollar (kg N eq/$)	Percent of Total N Emissions
541700	Scientific research and development services	59.2356752	$1,005,899.08	0.00006	20.0
322291	Sanitary paper product manufacturing	48.17176641	$261,369.47	0.00018	16.3
322120	Paper mills	44.73579557	$191,641.63	0.00023	15.1
334111	Electronic computer manufacturing	40.27319213	$300,532.02	0.00013	13.6
334220	Broadcast and wireless communications equipment	9.181714979	$227,761.90	0.00004	3.1
325610	Soap and cleaning compound manufacturing	8.476050959	$99,377.91	0.00009	2.9
339111	Laboratory apparatus and furniture manufacturing	8.225972911	$233,517.85	0.00004	2.8
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	4.690058644	$45,233.76	0.00010	1.6
334516	Analytical laboratory instrument manufacturing	4.456184163	$133,779.37	0.00003	1.5
33411A	Computer terminals and other computer peripheral equipment manufacturing	4.429860274	$65,467.33	0.00007	1.5

Top 10 Product Categories Ranked by Ozone Depletion					
IO CODE	Product Category	Environmental Impact (kg CFC-11 eq)	Dollar Amount Spent	Environmental Impact per Dollar (kg CFC-11 eq/$)	Percent of Total CFC-11 eq Emissions
322291	Sanitary paper product manufacturing	0.530660468	$261,369.47	2.03E-06	13.0
322120	Paper mills	0.479353756	$191,641.63	2.50E-06	11.7
541700	Scientific research and development services	0.477839738	$1,005,899.08	4.75E-07	11.7
334111	Electronic computer manufacturing	0.448838116	$300,532.02	1.49E-06	11.0
325188	All other basic inorganic chemical manufacturing	0.292833397	$24,266.85	1.21E-05	7.2
339111	Laboratory apparatus and furniture manufacturing	0.262176127	$233,517.85	1.12E-06	6.4
325610	Soap and cleaning compound manufacturing	0.212543958	$99,377.91	2.14E-06	5.2
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	0.145874537	$45,233.76	3.22E-06	3.6
334220	Broadcast and wireless communications equipment	0.137738029	$227,761.90	6.05E-07	3.4
325220	Artificial and synthetic fibers and filaments manufacturing	0.114099319	$5,430.86	2.10E-05	2.8

Top 10 Product Categories Ranked by Human Health - Criteria Air Pollutants					
IO CODE	Product Category	Environmental Impact (kg PM10 eq)	Dollar Amount Spent	Environmental Impact per Dollar (kg PM10 eq/$)	Percent of Total PM10 Emissions
322291	Sanitary paper product manufacturing	327.6023	$261,369.47	0.00125	17.7
322120	Paper mills	319.5430	$191,641.63	0.00167	17.3
541700	Scientific research and development services	299.2891	$1,005,899.08	0.00030	16.2
334111	Electronic computer manufacturing	212.7427	$300,532.02	0.00071	11.5
325610	Soap and cleaning compound manufacturing	60.4685	$99,377.91	0.00061	3.3
339111	Laboratory apparatus and furniture manufacturing	58.8388	$233,517.85	0.00025	3.2
334220	Broadcast and wireless communications equipment	49.8900	$227,761.90	0.00022	2.7
111400	Greenhouse, nursery, and floriculture production	37.7449	$1,103.50	0.03420	2.0
322230	Stationery product manufacturing	28.6001	$38,139.33	0.00075	1.5
3259A0	All other chemical product and preparation manufacturing	28.5941	$37,592.43	0.00076	1.5

Top 10 Product Categories Ranked by Smog Formation					
IO CODE	Product Category	Environmental Impact (kg O3 eq)	Dollar Amount Spent	Environmental Impact per Dollar (kg O3 eq/$)	Percent of Total O3 Emissions
541700	Scientific research and development services	28,620.4703	$1,005,899.08	0.02845	18.8
322291	Sanitary paper product manufacturing	24,692.7630	$261,369.47	0.09447	16.2
322120	Paper mills	22,932.1648	$191,641.63	0.11966	15.1
334111	Electronic computer manufacturing	21,933.6512	$300,532.02	0.07298	14.4
334220	Broadcast and wireless communications equipment	4,992.0189	$227,761.90	0.02192	3.3
339111	Laboratory apparatus and furniture manufacturing	4,343.8937	$233,517.85	0.01860	2.9
325610	Soap and cleaning compound manufacturing	4,104.4831	$99,377.91	0.04130	2.7
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	2,590.8844	$45,233.76	0.05728	1.7
33411A	Computer terminals and other computer peripheral equipment manufacturing	2,420.2617	$65,467.33	0.03697	1.6
334516	Analytical laboratory instrument manufacturing	2,378.9343	$133,779.37	0.01778	1.6

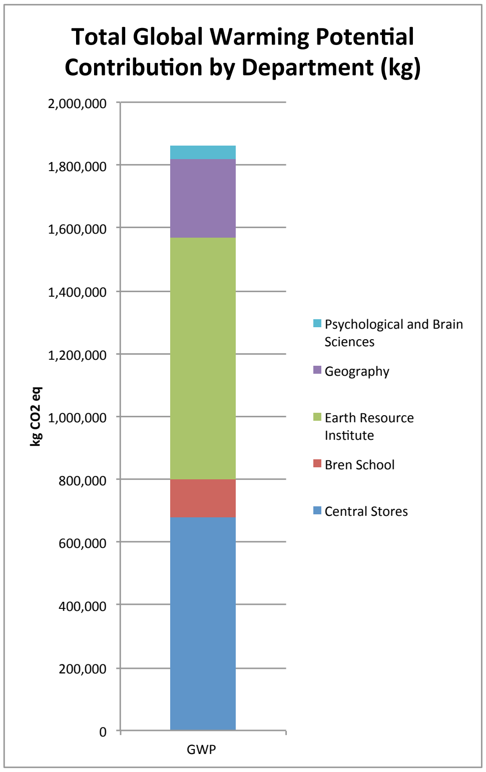
Top 10 Product Categories Ranked by Ecotoxicity					
IO CODE	Prodcut Category	Environmental Impact (CTUE)	Dollar Amount Spent	Environmental Impact per Dollar (CTUE/$)	Percent of Total CTUE Emissions
541700	Scientific research and development services	112296.5484	$1,005,899.08	0.111638	17.1
322291	Sanitary paper product manufacturing	86330.54158	$261,369.47	0.330301	13.2
325220	Artificial and synthetic fibers and filaments manufacturing	74978.83149	$5,430.86	13.806070	11.4
322120	Paper mills	66710.4059	$191,641.63	0.348100	10.2
334111	Electronic computer manufacturing	46973.71642	$300,532.02	0.156302	7.2
111400	Greenhouse, nursery, and floriculture production	23977.95484	$1,103.50	21.729003	3.7
313100	Fiber, yarn, and thread mills	18264.16615	$553.86	32.976142	2.8
339111	Laboratory apparatus and furniture manufacturing	17608.53225	$233,517.85	0.075406	2.7
325610	Soap and cleaning compound manufacturing	16028.62309	$99,377.91	0.161290	2.4
334220	Broadcast and wireless communications equipment	13153.65811	$227,761.90	0.057752	2.0

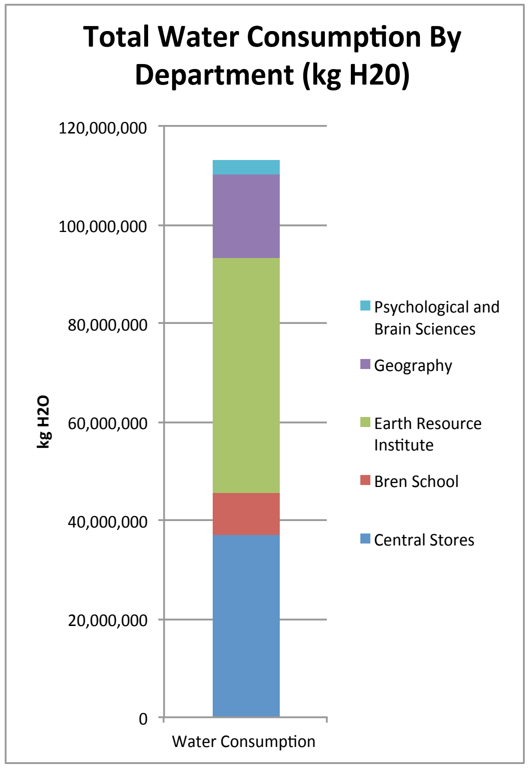
Top 10 Product Categories Ranked by Human Health - Carcinogenic					
IO CODE	Product Category	Environmental Impact (CTUHcan)	Dollar Amount Spent	Environmental Impact per Dollar (CTUHcan/$)	Percent of Total CTUH Emissions
322291	Sanitary paper product manufacturing	2.292E-04	$261,369.47	8.767E-10	18.0
322120	Paper mills	2.237E-04	$191,641.63	1.167E-09	17.6
334111	Electronic computer manufacturing	1.719E-04	$300,532.02	5.721E-10	13.5
541700	Scientific research and development services	1.710E-04	$1,005,899.08	1.700E-10	13.4
339111	Laboratory apparatus and furniture manufacturing	4.428E-05	$233,517.85	1.896E-10	3.5
334220	Broadcast and wireless communications equipment	4.185E-05	$227,761.90	1.838E-10	3.3
325610	Soap and cleaning compound manufacturing	3.976E-05	$99,377.91	4.001E-10	3.1
325188	All other basic inorganic chemical manufacturing	2.097E-05	$24,266.85	8.641E-10	1.6
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	2.044E-05	$45,233.76	4.519E-10	1.6
33411A	Computer terminals and other computer peripheral equipment manufacturing	2.017E-05	$65,467.33	3.081E-10	1.6

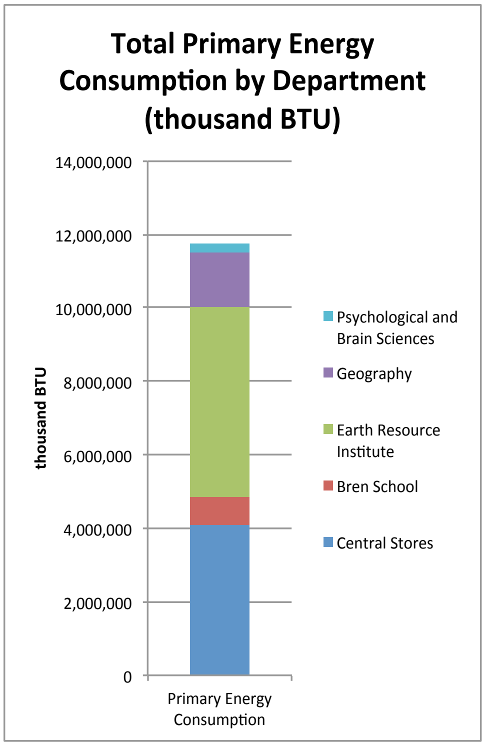
Top 10 Product Categories Ranked by Human Health - Non-Carcinogenic					
IO CODE	Product Category	Environmental Impact (CTUHnoncan)	Dollar Amount Spent	Environmental Impact per Dollar (CTUHnoncan/$)	Percent of Total CTUHnoncan Emissions
334111	Electronic computer manufacturing	1.056E-02	$300,532.02	3.514E-08	16.6
322120	Paper mills	9.361E-03	$191,641.63	4.884E-08	14.8
322291	Sanitary paper product manufacturing	9.347E-03	$261,369.47	3.576E-08	14.7
541700	Scientific research and development services	6.716E-03	$1,005,899.08	6.676E-09	10.6
334220	Broadcast and wireless communications equipment	2.855E-03	$227,761.90	1.253E-08	4.5
325610	Soap and cleaning compound manufacturing	2.176E-03	$99,377.91	2.190E-08	3.4
339111	Laboratory apparatus and furniture manufacturing	1.921E-03	$233,517.85	8.228E-09	3.0
325188	All other basic inorganic chemical manufacturing	1.556E-03	$24,266.85	6.413E-08	2.5
33411A	Computer terminals and other computer peripheral equipment manufacturing	1.229E-03	$65,467.33	1.878E-08	1.9
334516	Analytical laboratory instrument manufacturing	1.184E-03	$133,779.37	8.851E-09	1.9

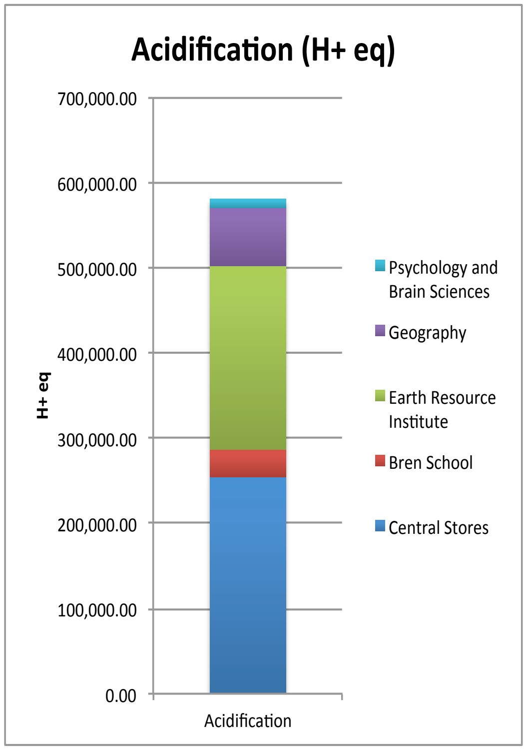
Top 10 Product Categories Ranked by Land Use					
IO CODE	Product Category	Environmental Impact (acres)	Dollar Amount Spent	Environmental Impact per Dollar (acres/$)	Percent of Total Land Use
322120	Paper mills	332.7835	$191,641.63	1.736E-03	36.4
322291	Sanitary paper product manufacturing	283.7485	$261,369.47	1.086E-03	31.0
541700	Scientific research and development services	52.2015	$1,005,899.08	5.190E-05	5.7
334111	Electronic computer manufacturing	50.0096	$300,532.02	1.664E-04	5.5
339111	Laboratory apparatus and furniture manufacturing	42.2919	$233,517.85	1.811E-04	4.6
322230	Stationery product manufacturing	25.2967	$38,139.33	6.633E-04	2.8
321100	Sawmills and wood preservation	12.1394	$982.74	1.235E-02	1.3
325610	Soap and cleaning compound manufacturing	9.5943	$99,377.91	9.654E-05	1.0
334220	Broadcast and wireless communications equipment	8.2807	$227,761.90	3.636E-05	0.9
33411A	Computer terminals and other computer peripheral equipment manufacturing	7.6310	$65,467.33	1.166E-04	0.8

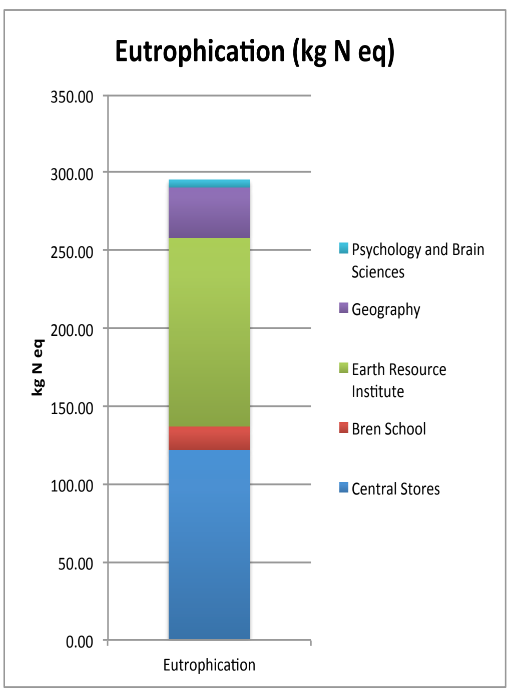
Appendix 3: Proportion of each TRACI environmental impact category by department

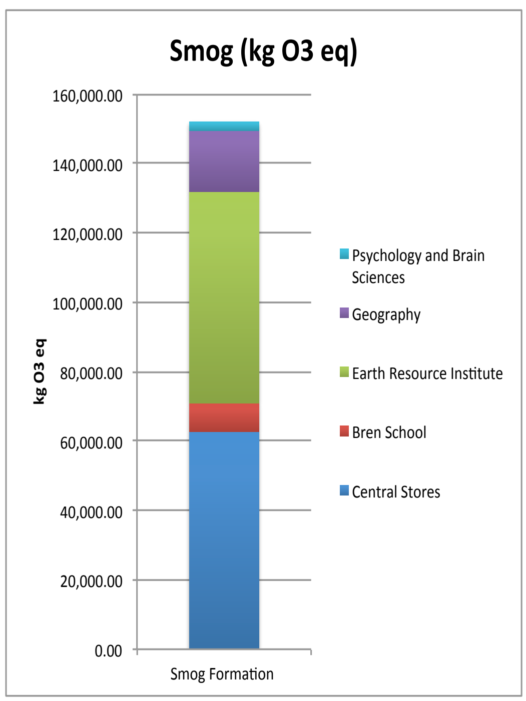


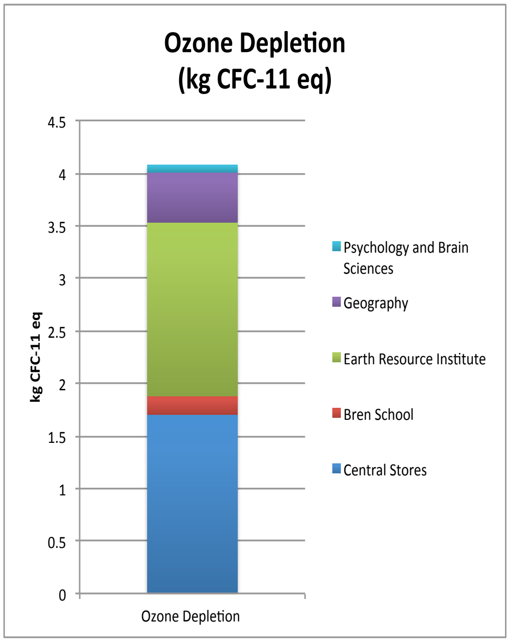


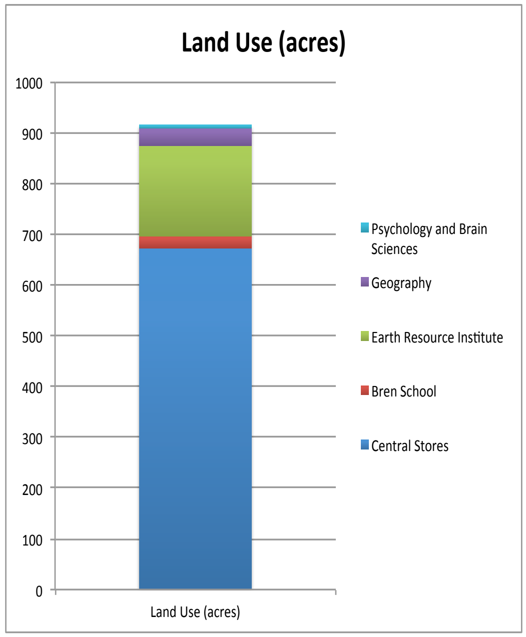

Total Primary Energy Consumption by Department (thousand BTU)
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
thousand BTU
Primary Energy Consumption
Psychological and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores

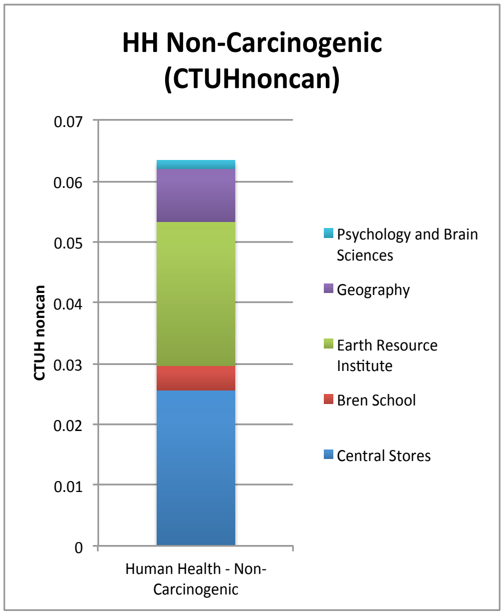

Acidification (H+ eq)
700,000.00
600,000.00
500,000.00
400,000.00
300,000.00
200,000.00
100,000.00
0.00
H+ eq
Acidification
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores

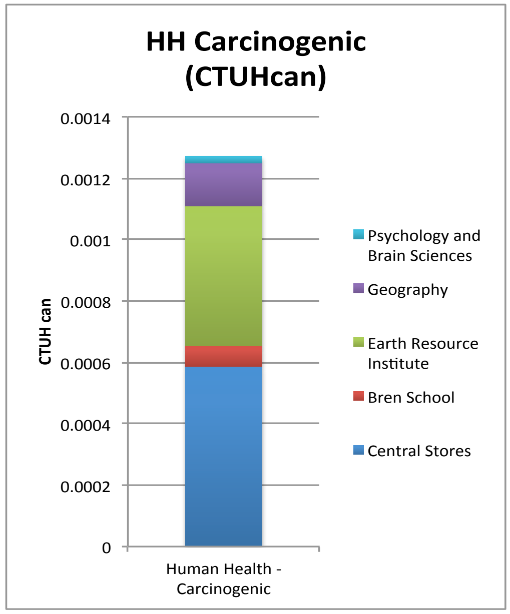

Eutrophication (kg N eq)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
kg N eq
Eutrophication
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores

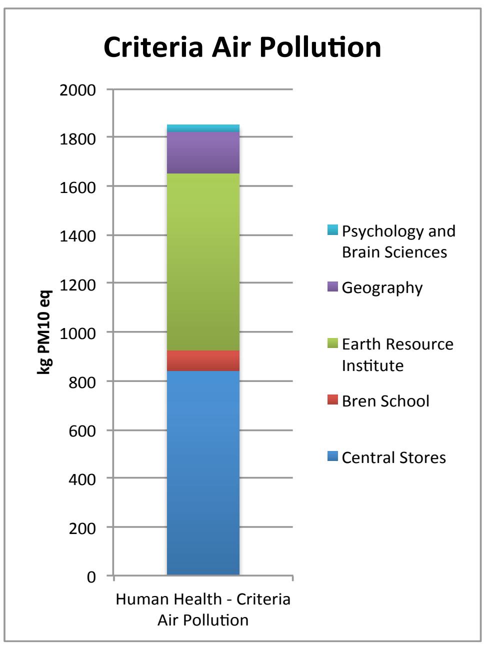

Smog (kg O3 eq)
160,000.00
140,000.00
120,000.00
100,000.00
80,000.00
60,000.00
40,000.00
20,000.00
0.00
kg O3 eq
Smog Formation
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores

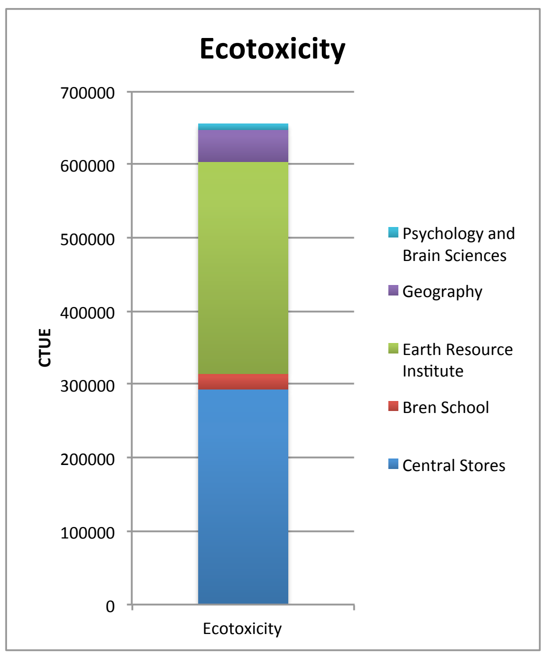

Ozone Depletion
(kg CFC-11 eq)
kg CFC-11 eq
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Ozone Depletion
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores


Land Use (acres)
1000
900
800
700
600
500
400
300
200
100
0
Land Use (acres)
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores


HH Non-Carcinogenic (CTUHnoncan)
CTUH noncan
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Human Health - Non-Carcinogenic
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores


HH Carcinogenic (CTUHcan)
CTUH can
0.0014
0.0012
0.001
0.0008
0.0006
0.0004
0.0002
0
Human Health - Carcinogenic
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores


Criteria Air Pollution
kg PM10 eq
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Human Health - Criteria Air Pollution
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores


Ecotoxicity
CTUE
700000
600000
500000
400000
300000
200000
100000
0
Ecotoxicity
Psychology and Brain Sciences
Geography
Earth Resource Institute
Bren School
Central Stores

APPENDIX 4: CEDA Results – Top 10 Product Categories for All Environmental Impact Categories By Department

Department of Psychology & Brain Sciences

Department of Psychology Life Cycle Impact Assessment – Acidification					
IO Code	IO Code Description	Impact Subtotals (H+ moles eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	7079	$24,839	0.28	67%
334210	Telephone apparatus manufacturing	1086	$10,469	0.10	10%
3259A0	All other chemical product and preparation manufacturing	294	$1,174	0.25	3%
339113	Surgical appliance and supplies manufacturing	284	$3,085	0.09	3%
334112	Computer storage device manufacturing	244	$2,459	0.10	2%
811200	Electronic and precision equipment repair and maintenance	241	$6,817	0.04	2%
334419	Other electronic component manufacturing	227	$2,612	0.09	2%
335911	Storage battery manufacturing	144	$732	0.20	1%
325212	Synthetic rubber manufacturing	133	$516	0.26	1%
33131A	Alumina refining and primary aluminum production	82	$88	0.93	1%
	Other product categories	760	$7,894	0.10	7%
TOTALS:		**10571**	**$60,684**	**0.17**	**100%**

Department of Psychology Life Cycle Impact Assessment - Ecotoxicity					
IO Code	IO Code Description	Impact Subtotals (CTUE)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	3882	$24,839	0.16	47%
339113	Surgical appliance and supplies manufacturing	1068	$3,085	0.35	13%
313320	Fabric coating mills	663	$366	1.81	8%
334210	Telephone apparatus manufacturing	644	$10,469	0.06	8%
562000	Waste management and remediation services	415	$80	5.19	5%
3259A0	All other chemical product and preparation manufacturing	249	$1,174	0.21	3%
811200	Electronic and precision equipment repair and maintenance	169	$6,817	0.02	2%
334419	Other electronic component manufacturing	135	$2,612	0.05	2%
334112	Computer storage device manufacturing	123	$2,459	0.05	2%
32121A	Veneer and plywood manufacturing	106	$120	0.88	1%
	Other product categories	757	$8,664	0.09	9%
TOTALS:		**8212**	**$60,684**	**0.14**	**100%**

Department of Psychology Life Cycle Impact Assessment - Eutrophication					
IO Code	IO Code Description	Impact Subtotals (kg N eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	3.33	24,839	0.00	67%
334210	Telephone apparatus manufacturing	0.52	10,469	0.00	10%
339113	Surgical appliance and supplies manufacturing	0.15	3,085	0.00	3%
3259A0	All other chemical product and preparation manufacturing	0.13	1,174	0.00	3%
334112	Computer storage device manufacturing	0.11	2,459	0.00	2%
811200	Electronic and precision equipment repair and maintenance	0.10	6,817	0.00	2%
334419	Other electronic component manufacturing	0.10	2,612	0.00	2%
325212	Synthetic rubber manufacturing	0.07	516	0.00	1%
313320	Fabric coating mills	0.05	366	0.00	1%
325411	Medicinal and botanical manufacturing	0.04	973	0.00	1%
	Other product categories	0	7,375	0.00	8%
TOTALS:		**5**	**$60,684**	**0.00**	**100%**

Department of Psychology Life Cycle Impact Assessment - Global Warming Potential					
IO Code	IO Code Description	Impact Subtotals (kg CO2 eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	27487	24,839	1.11	67%
334210	Telephone apparatus manufacturing	4497	10,469	0.43	11%
339113	Surgical appliance and supplies manufacturing	1236	3,085	0.40	3%
811200	Electronic and precision equipment repair and maintenance	948	6,817	0.14	2%
334112	Computer storage device manufacturing	913	2,459	0.37	2%
3259A0	All other chemical product and preparation manufacturing	902	1,174	0.77	2%
334419	Other electronic component manufacturing	863	2,612	0.33	2%
325212	Synthetic rubber manufacturing	608	516	1.18	1%
335911	Storage battery manufacturing	317	732	0.43	1%
325411	Medicinal and botanical manufacturing	272	973	0.28	1%
	Other product categories	2995	7,009	0.43	7%
TOTALS:		**41039**	**$60,684**	**0.68**	**100%**

Department of Psychology Life Cycle Impact Assessment -Human Health Criteria Air Pollution					
IO Code	**IO Code Description**	**Impact Subtotals (kg PM10 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	17.58	24,839	0.00	64%
334210	Telephone apparatus manufacturing	2.85	10,469	0.00	10%
339113	Surgical appliance and supplies manufacturing	0.90	3,085	0.00	3%
3259A0	All other chemical product and preparation manufacturing	0.89	1,174	0.00	3%
334112	Computer storage device manufacturing	0.59	2,459	0.00	2%
811200	Electronic and precision equipment repair and maintenance	0.58	6,817	0.00	2%
334419	Other electronic component manufacturing	0.56	2,612	0.00	2%
32121A	Veneer and plywood manufacturing	0.49	120	0.00	2%
325212	Synthetic rubber manufacturing	0.44	516	0.00	2%
313320	Fabric coating mills	0.29	366	0.00	1%
	Other product categories	2	8,228	0.00	9%
TOTALS:		**28**	**60,684**	**0.00**	**100%**

Department of Psychology Life Cycle Impact Assessment - Human Health Carcinogen					
IO Code	**IO Code Description**	**Impact Subtotals (CTUHcan)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	0.00	24,839	0.00	62%
334210	Telephone apparatus manufacturing	0.00	10,469	0.00	11%
339113	Surgical appliance and supplies manufacturing	0.00	3,085	0.00	3%
3259A0	All other chemical product and preparation manufacturing	0.00	1,174	0.00	2%
334419	Other electronic component manufacturing	0.00	2,612	0.00	2%
325212	Synthetic rubber manufacturing	0.00	516	0.00	2%
334112	Computer storage device manufacturing	0.00	2,459	0.00	2%
811200	Electronic and precision equipment repair and maintenance	0.00	6,817	0.00	2%
335911	Storage battery manufacturing	0.00	732	0.00	1%
335110	Electric lamp bulb and part manufacturing	0.00	465	0.00	1%
	Other product categories	0	7,518	0.00	10%
TOTALS:		**0**	**$60,684**	**0.00**	**100%**

Department of Psychology Life Cycle Impact Assessment - Human Health Non Carcinogen					
IO Code	IO Code Description	Impact Subtotals (CTUHnoncan)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	0.00	24,839	0.00	61%
334210	Telephone apparatus manufacturing	0.00	10,469	0.00	11%
334419	Other electronic component manufacturing	0.00	2,612	0.00	3%
335911	Storage battery manufacturing	0.00	732	0.00	2%
562000	Waste management and remediation services	0.00	80	0.00	2%
339113	Surgical appliance and supplies manufacturing	0.00	3,085	0.00	2%
335110	Electric lamp bulb and part manufacturing	0.00	465	0.00	2%
3259A0	All other chemical product and preparation manufacturing	0.00	1,174	0.00	2%
33131A	Alumina refining and primary aluminum production	0.00	88	0.00	2%
334112	Computer storage device manufacturing	0.00	2,459	0.00	2%
	Other product categories	0	14,683	0.00	9%
TOTALS:		**0**	**$60,684**	**0.00**	**100%**

Department of Psychology Life Cycle Impact Assessment - Land Use					
IO Code	IO Code Description	Impact Subtotals (Acres)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	4.13	$24,839	0.00	61%
32121A	Veneer and plywood manufacturing	1.01	$120	0.01	15%
334210	Telephone apparatus manufacturing	0.45	$10,469	0.00	7%
339113	Surgical appliance and supplies manufacturing	0.18	$3,085	0.00	3%
334112	Computer storage device manufacturing	0.15	$2,459	0.00	2%
339111	Laboratory apparatus and furniture manufacturing	0.14	$800	0.00	2%
3259A0	All other chemical product and preparation manufacturing	0.10	$1,174	0.00	1%
811200	Electronic and precision equipment repair and maintenance	0.09	$6,817	0.00	1%
334419	Other electronic component manufacturing	0.08	$2,612	0.00	1%
313320	Fabric coating mills	0.04	$366	0.00	1%
	Other product categories	0	$7,944	0.00	6%
TOTALS:		**7**	**$60,684**	**0.00**	**100%**

Department of Psychology Life Cycle Impact Assessment - Ozone Depletion Air					
IO Code	**IO Code Description**	**Impact Subtotals (kg CFC-11 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	0.0371	24,839	0.00	51%
334210	Telephone apparatus manufacturing	0.0071	10,469	0.00	10%
325212	Synthetic rubber manufacturing	0.0058	516	0.00	8%
334419	Other electronic component manufacturing	0.0042	2,612	0.00	6%
339113	Surgical appliance and supplies manufacturing	0.0036	3,085	0.00	5%
3259A0	All other chemical product and preparation manufacturing	0.0031	1,174	0.00	4%
339112	Surgical and medical instrument manufacturing	0.0015	603	0.00	2%
313320	Fabric coating mills	0.0012	366	0.00	2%
334512	Automatic environmental control manufacturing	0.0009	246	0.00	1%
334112	Computer storage device manufacturing	0.0009	2,459	0.00	1%
	Other product categories	0.0067	14,316	0.00	9%
TOTALS:		**0.0722**	**$60,684**	**0.00**	**100%**

Department of Psychology Life Cycle Impact Assessment - Primary Energy Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (thousand BTU)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	321533	24,839	12.94	68%
334210	Telephone apparatus manufacturing	52705	10,469	5.03	11%
811200	Electronic and precision equipment repair and maintenance	13420	6,817	1.97	3%
339113	Surgical appliance and supplies manufacturing	12279	3,085	3.98	3%
334112	Computer storage device manufacturing	9945	2,459	4.04	2%
3259A0	All other chemical product and preparation manufacturing	9856	1,174	8.40	2%
334419	Other electronic component manufacturing	8847	2,612	3.39	2%
325212	Synthetic rubber manufacturing	5908	516	11.45	1%
325411	Medicinal and botanical manufacturing	4484	973	4.61	1%
335911	Storage battery manufacturing	3251	732	4.44	1%
	Other product categories	31019	7,009	4.43	7%
TOTALS:		**473248**	**60,684**	**7.80**	**100%**

Department of Psychology Life Cycle Impact Assessment - Smog Air					
IO Code	**IO Code Description**	**Impact Subtotals (kg O3 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	1813	$24,839	0.07	67%
334210	Telephone apparatus manufacturing	286	$10,469	0.03	11%
339113	Surgical appliance and supplies manufacturing	82	$3,085	0.03	3%
3259A0	All other chemical product and preparation manufacturing	67	$1,174	0.06	2%
334112	Computer storage device manufacturing	59	$2,459	0.02	2%
811200	Electronic and precision equipment repair and maintenance	57	$6,817	0.01	2%
334419	Other electronic component manufacturing	54	$2,612	0.02	2%
325212	Synthetic rubber manufacturing	38	$516	0.07	1%
313320	Fabric coating mills	28	$366	0.08	1%
335911	Storage battery manufacturing	22	$732	0.03	1%
	Other product categories	200	$7,616	0.03	7%
TOTALS:		**2706**	**$60,684**	**0.04**	**100%**

Department of Psychology Life Cycle Impact Assessment - Water Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (kg)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	2029270	24,839	81.70	71%
334210	Telephone apparatus manufacturing	290556	10,469	27.75	10%
339113	Surgical appliance and supplies manufacturing	78436	3,085	25.42	3%
334112	Computer storage device manufacturing	69223	2,459	28.15	2%
811200	Electronic and precision equipment repair and maintenance	62232	6,817	9.13	2%
334419	Other electronic component manufacturing	54974	2,612	21.05	2%
3259A0	All other chemical product and preparation manufacturing	40948	1,174	34.89	1%
313320	Fabric coating mills	21441	366	58.58	1%
325212	Synthetic rubber manufacturing	20492	516	39.71	1%
325414	Biological product (except diagnostic) manufacturing	18914	1,244	15.20	1%
	Other product categories	176543	7,104	24.85	6%
TOTALS:		**2863031**	**60,684**	**47.18**	**100%**

Earth Research Institute

Earth Research Institute Life Cycle Impact Assessment - Acidification					
IO Code	IO Code Description	Impact Subtotals (H+ moles eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
541700	Scientific research and development services	91,952	1,005,899	0.09	43%
334111	Electronic computer manufacturing	28,826	101,151	0.28	13%
339111	Laboratory apparatus and furniture manufacturing	14,595	224,554	0.06	7%
334516	Analytical laboratory instrument manufacturing	8,952	129,569	0.07	4%
5416A0	Environmental and other technical consulting services	5,622	212,623	0.03	3%
325188	All other basic inorganic chemical manufacturing	5,064	15,502	0.33	2%
325211	Plastics material and resin manufacturing	4,679	15,496	0.30	2%
33411A	Computer terminals and other computer peripheral equipment manufacturing	4,670	33,296	0.14	2%
331110	Iron and steel mills and ferroalloy manufacturing	3,992	13,725	0.29	2%
32619A	Other plastics product manufacturing	3,472	18,730	0.19	2%
	Other product categories	43,590	433,598	0.10	20%
TOTALS:		**215,413**	**2,204,143**	**0.10**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Ecotoxicity					
IO Code	IO Code Description	Impact Subtotals (CTUE)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
541700	Scientific research and development services	112,297	1,005,899	0.11	39%
111400	Greenhouse, nursery, and floriculture production	23,978	1,104	21.73	8%
339111	Laboratory apparatus and furniture manufacturing	16,933	224,554	0.08	6%
334111	Electronic computer manufacturing	15,810	101,151	0.16	5%
313220	Narrow fabric mills and schiffli machine embroidery	12,777	2,240	5.70	4%
313100	Fiber, yarn, and thread mills	10,651	323	32.98	4%
562000	Waste management and remediation services	10,114	1,948	5.19	3%
325220	Artificial and synthetic fibers and filaments manufacturing	9,920	719	13.81	3%
5416A0	Environmental and other technical consulting services	9,793	212,623	0.05	3%
334516	Analytical laboratory instrument manufacturing	6,265	129,569	0.05	2%
	Other product categories	61,050	524,014	0.12	21%
TOTALS:		**289,587**	**2,204,143**	**0.13**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Eutrophication					
IO Code	IO Code Description	Impact Subtotals (kg N eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
541700	Scientific research and development services	59	1,005,899	0.00	49%
334111	Electronic computer manufacturing	14	101,151	0.00	11%
339111	Laboratory apparatus and furniture manufacturing	8	224,554	0.00	7%
334516	Analytical laboratory instrument manufacturing	4	129,569	0.00	4%
5416A0	Environmental and other technical consulting services	3	212,623	0.00	2%
325211	Plastics material and resin manufacturing	3	15,496	0.00	2%
33411A	Computer terminals and other computer peripheral equipment manufacturing	2	33,296	0.00	2%
331110	Iron and steel mills and ferroalloy manufacturing	2	13,725	0.00	2%
325188	All other basic inorganic chemical manufacturing	2	15,502	0.00	2%
32619A	Other plastics product manufacturing	2	18,730	0.00	1%
	Other product categories	23	433,598	0.00	19%
TOTALS:		**121**	**2,204,143**	**0.00**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Global Warming Potential					
IO Code	IO Code Description	Impact Subtotals (kg CO2 eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
541700	Scientific research and development services	252,576	1,005,899	0.25	33%
334111	Electronic computer manufacturing	111,935	101,151	1.11	15%
339111	Laboratory apparatus and furniture manufacturing	62,007	224,554	0.28	8%
334516	Analytical laboratory instrument manufacturing	36,017	129,569	0.28	5%
331110	Iron and steel mills and ferroalloy manufacturing	33,040	13,725	2.41	4%
325211	Plastics material and resin manufacturing	26,322	15,496	1.70	3%
325188	All other basic inorganic chemical manufacturing	24,430	15,502	1.58	3%
5416A0	Environmental and other technical consulting services	23,636	212,623	0.11	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	19,317	33,296	0.58	3%
32619A	Other plastics product manufacturing	15,441	18,730	0.82	2%
	Other product categories	161,694	433,598	0.37	21%
TOTALS:		**766,415**	**2,204,143**	**0.35**	**100%**

Earth Research Institute Life Cycle Impact Assessment -Human Health Criteria Air Pollution					
IO Code	IO Code Description	Impact Subtotals (kg PM10 eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
541700	Scientific research and development services	299	1,005,899	0.00	41%
334111	Electronic computer manufacturing	72	101,151	0.00	10%
339111	Laboratory apparatus and furniture manufacturing	57	224,554	0.00	8%
111400	Greenhouse, nursery, and floriculture production	38	1,104	0.03	5%
334516	Analytical laboratory instrument manufacturing	24	129,569	0.00	3%
212320	Sand, gravel, clay, and ceramic and refractory minerals mining and quarrying	18	7,755	0.00	3%
325211	Plastics material and resin manufacturing	17	15,496	0.00	2%
5416A0	Environmental and other technical consulting services	16	212,623	0.00	2%
325188	All other basic inorganic chemical manufacturing	15	15,502	0.00	2%
331110	Iron and steel mills and ferroalloy manufacturing	15	13,725	0.00	2%
	Other product categories	156	476,765	0.00	21%
TOTALS:		**727**	**2,204,143**	**0.00**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Human Health Carcinogen					
IO Code	IO Code Description	Impact Subtotals (CTUHcan)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
541700	Scientific research and development services	0.0002	1,005,899	0.00	37%
334111	Electronic computer manufacturing	0.0001	101,151	0.00	13%
339111	Laboratory apparatus and furniture manufacturing	0.0000	224,554	0.00	9%
334516	Analytical laboratory instrument manufacturing	0.0000	129,569	0.00	4%
5416A0	Environmental and other technical consulting services	0.0000	212,623	0.00	3%
325188	All other basic inorganic chemical manufacturing	0.0000	15,502	0.00	3%
325211	Plastics material and resin manufacturing	0.0000	15,496	0.00	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	0.0000	33,296	0.00	2%
32619A	Other plastics product manufacturing	0.0000	18,730	0.00	2%
331110	Iron and steel mills and ferroalloy manufacturing	0.0000	13,725	0.00	2%
	Other product categories	0.0001	433,598	0.00	22%
TOTALS:		**0.0005**	**2,204,143**	**0.00**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Human Health Non Carcinogen					
IO Code	**IO Code Description**	**Impact Subtotals (CTUHnoncan)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
541700	Scientific research and development services	0.0067	1,005,899	0.00	28%
334111	Electronic computer manufacturing	0.0036	101,151	0.00	15%
339111	Laboratory apparatus and furniture manufacturing	0.0018	224,554	0.00	8%
334516	Analytical laboratory instrument manufacturing	0.0011	129,569	0.00	5%
325188	All other basic inorganic chemical manufacturing	0.0010	15,502	0.00	4%
5416A0	Environmental and other technical consulting services	0.0010	212,623	0.00	4%
562000	Waste management and remediation services	0.0008	1,948	0.00	3%
331110	Iron and steel mills and ferroalloy manufacturing	0.0007	13,725	0.00	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	0.0006	33,296	0.00	3%
325211	Plastics material and resin manufacturing	0.0005	15,496	0.00	2%
	Other product categories	0.0058	450,380	0.00	25%
TOTALS:		**0.0237**	**2,204,143**	0.00	100%

Earth Research Institute Life Cycle Impact Assessment - Land Use					
IO Code	**IO Code Description**	**Impact Subtotals (Acres)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
541700	Scientific research and development services	52	1,005,899	0.00	29%
339111	Laboratory apparatus and furniture manufacturing	41	224,554	0.00	23%
334111	Electronic computer manufacturing	17	101,151	0.00	9%
321100	Sawmills and wood preservation	12	983	0.01	7%
321910	Wood windows and doors and millwork	6	1,420	0.00	3%
322120	Paper mills	5	2,892	0.00	3%
334516	Analytical laboratory instrument manufacturing	4	129,569	0.00	2%
5416A0	Environmental and other technical consulting services	4	212,623	0.00	2%
322130	Paperboard Mills	4	1,647	0.00	2%
33411A	Computer terminals and other computer peripheral equipment manufacturing	4	33,296	0.00	2%
	Other product categories	29	490,109	0.00	16%
TOTALS:		**178**	**2,204,143**	**0.00**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Ozone Depletion Air					
IO Code	**IO Code Description**	**Impact Subtotals (kg CFC-11 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
541700	Scientific research and development services	0.48	1,005,899	0.00	29%
339111	Laboratory apparatus and furniture manufacturing	0.25	224,554	0.00	15%
325188	All other basic inorganic chemical manufacturing	0.19	15,502	0.00	11%
334111	Electronic computer manufacturing	0.15	101,151	0.00	9%
325211	Plastics material and resin manufacturing	0.09	15,496	0.00	5%
334516	Analytical laboratory instrument manufacturing	0.06	129,569	0.00	4%
32619A	Other plastics product manufacturing	0.05	18,730	0.00	3%
111400	Greenhouse, nursery, and floriculture production	0.04	1,104	0.00	3%
325212	Synthetic rubber manufacturing	0.04	3,547	0.00	2%
33411A	Computer terminals and other computer peripheral equipment manufacturing	0.02	33,296	0.00	1%
	Other product categories	0.28	655,295	0.00	17%
TOTALS:		**1.65**	**2,204,143**	**0.00**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Primary Energy Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (thousand BTU)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
541700	Scientific research and development services	4,034,349	1,005,899	4.01	39%
334111	Electronic computer manufacturing	1,309,382	101,151	12.94	13%
492000	Couriers and messengers	886,443	38,900	22.79	9%
339111	Laboratory apparatus and furniture manufacturing	691,268	224,554	3.08	7%
334516	Analytical laboratory instrument manufacturing	411,482	129,569	3.18	4%
5416A0	Environmental and other technical consulting services	344,491	212,623	1.62	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	240,348	33,296	7.22	2%
325211	Plastics material and resin manufacturing	236,475	15,496	15.26	2%
32619A	Other plastics product manufacturing	178,151	18,730	9.51	2%
325188	All other basic inorganic chemical manufacturing	141,124	15,502	9.10	1%
	Other product categories	1,845,780	408,423	4.52	18%
TOTALS:		**10,319,292**	**2,204,143**	**4.68**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Primary Energy Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (thousand BTU)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
541700	Scientific research and development services	4,034,349	1,005,899	4.01	39%
334111	Electronic computer manufacturing	1,309,382	101,151	12.94	13%
492000	Couriers and messengers	886,443	38,900	22.79	9%
339111	Laboratory apparatus and furniture manufacturing	691,268	224,554	3.08	7%
334516	Analytical laboratory instrument manufacturing	411,482	129,569	3.18	4%
5416A0	Environmental and other technical consulting services	344,491	212,623	1.62	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	240,348	33,296	7.22	2%
325211	Plastics material and resin manufacturing	236,475	15,496	15.26	2%
32619A	Other plastics product manufacturing	178,151	18,730	9.51	2%
325188	All other basic inorganic chemical manufacturing	141,124	15,502	9.10	1%
	Other product categories	1,845,780	408,423	4.52	18%
TOTALS:		**10,319,292**	**2,204,143**	**4.68**	**100%**

Earth Research Institute Life Cycle Impact Assessment - Water Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (kg)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
541700	Scientific research and development services	17,924,512	$1,005,899	17.82	38%
334111	Electronic computer manufacturing	8,263,826	$101,151	81.70	17%
339111	Laboratory apparatus and furniture manufacturing	4,202,789	$224,554	18.72	9%
334516	Analytical laboratory instrument manufacturing	2,479,696	$129,569	19.14	5%
5416A0	Environmental and other technical consulting services	1,424,647	$212,623	6.70	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	1,230,449	$33,296	36.96	3%
325211	Plastics material and resin manufacturing	801,923	$15,496	51.75	2%
32619A	Other plastics product manufacturing	789,913	$18,730	42.17	2%
325188	All other basic inorganic chemical manufacturing	737,274	$15,502	47.56	2%
334112	Computer storage device manufacturing	600,254	$21,322	28.15	1%
	Other product categories	9,165,000	$426,000	21.51	19%
TOTALS:		**47,620,284**	**$2,204,143**	**21.60**	**100%**

Department of Geography

Department of Geography Life Cycle Impact Assessment - Acidification					
IO Code	IO Code Description	Impact Subtotals (H+ moles eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	25647	89,995	0.28	38%
334220	Broadcast and wireless communications equipment	20234	225,426	0.09	13.98%
483000	Water transportation	3490	1,122	3.11	2.41%
325188	All other basic inorganic chemical manufacturing	2862	8,762	0.33	1.98%
511200	Software publishers	1778	58,473	0.03	1.23%
334413	Semiconductor and related device manufacturing	1437	5,581	0.26	0.99%
811200	Electronic and precision equipment repair and maintenance	1280	36,245	0.04	0.88%
335999	All other miscellaneous electrical equipment and component manufacturing	1238	7,246	0.17	0.86%
518200	Data processing, hosting, and related services	1145	27,342	0.04	0.79%
334290	Other communications equipment manufacturing	822	10,646	0.08	0.57%
	Other product categories	8280	97,447	0.08	12.14%
TOTALS:		**68,213**	**$568,284**	**0.08**	**100%**

Department of Geography Life Cycle Impact Assessment - Ecotoxicity					
IO Code	IO Code Description	Impact Subtotals (CTUE)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	14066	89,995	0.16	32%
334220	Broadcast and wireless communications equipment	13019	225,426	0.06	30%
337920	Blind and shade manufacturing	2776	2,637	1.05	6%
511200	Software publishers	1557	58,473	0.03	4%
518200	Data processing, hosting, and related services	1120	27,342	0.04	3%
325188	All other basic inorganic chemical manufacturing	974	8,762	0.11	2%
811200	Electronic and precision equipment repair and maintenance	901	36,245	0.02	2%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	725	4,122	0.18	2%
3259A0	All other chemical product and preparation manufacturing	578	2,729	0.21	1%
334413	Semiconductor and related device manufacturing	560	5,581	0.10	1%
	Other product categories	7264	106,973	0.07	17%
TOTALS:		**43540**	**568,284**	**0.07**	**100%**

Department of Geography Life Cycle Impact Assessment - Eutrophication					
IO Code	IO Code Description	Impact Subtotals (kg N eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	12.06	89,995	0.00	37%
334220	Broadcast and wireless communications equipment	9.09	225,426	0.00	28%
483000	Water transportation	2.70	1,122	0.00	8%
325188	All other basic inorganic chemical manufacturing	1.06	8,762	0.00	3%
511200	Software publishers	0.83	58,473	0.00	3%
518200	Data processing, hosting, and related services	0.59	27,342	0.00	2%
811200	Electronic and precision equipment repair and maintenance	0.56	36,245	0.00	2%
334413	Semiconductor and related device manufacturing	0.51	5,581	0.00	2%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	0.43	4,122	0.00	1%
335999	All other miscellaneous electrical equipment and component manufacturing	0.40	7,246	0.00	1%
	Other product categories	4	103,970	0.00	12%
TOTALS:		**32**	**568,284**	**0.00**	**100%**

Department of Geography Life Cycle Impact Assessment - Global Warming Potential					
IO Code	IO Code Description	Impact Subtotals (kg CO2 eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	99,589.47	$89,994.62	1.11	146%
334220	Broadcast and wireless communications equipment	76,680.82	$225,426.02	0.34	14.33%
325188	All other basic inorganic chemical manufacturing	13,807.78	$8,761.82	1.58	2.58%
511200	Software publishers	6,644.42	$58,473.06	0.11	1.24%
334413	Semiconductor and related device manufacturing	5,298.56	$5,580.64	0.95	0.99%
811200	Electronic and precision equipment repair and maintenance	5,039.39	$36,244.97	0.14	0.94%
518200	Data processing, hosting, and related services	4,584.66	$27,341.76	0.17	0.86%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	3,869.45	$4,122.42	0.94	0.72%
334290	Other communications equipment manufacturing	3,356.17	$10,645.50	0.32	0.63%
334112	Computer storage device manufacturing	2,114.30	$5,691.97	0.37	0.40%
	Other product categories	31098	96,001	0.32	45.59%
TOTALS:		**252,083**	**$568,284**	**0.32**	**100%**

Department of Geography Life Cycle Impact Assessment -Human Health Criteria Air Pollution					
IO Code	IO Code Description	Impact Subtotals (kg PM10 eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	64	89,995	0.00	37%
334220	Broadcast and wireless communications equipment	49	225,426	0.00	29%
325188	All other basic inorganic chemical manufacturing	8	8,762	0.00	5%
483000	Water transportation	6	1,122	0.01	3%
511200	Software publishers	5	58,473	0.00	3%
518200	Data processing, hosting, and related services	4	27,342	0.00	2%
334413	Semiconductor and related device manufacturing	3	5,581	0.00	2%
811200	Electronic and precision equipment repair and maintenance	3	36,245	0.00	2%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	3	4,122	0.00	2%
334290	Other communications equipment manufacturing	2	10,646	0.00	1%
	Other product categories	24	100,571	0.00	14%
TOTALS:		**171**	**568,284**	**0.00**	**100%**

Department of Geography Life Cycle Impact Assessment - Human Health Carcinogen					
IO Code	IO Code Description	Impact Subtotals (CTUHcan)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	0.0001	89,995	0.00	37%
334220	Broadcast and wireless communications equipment	0.0000	225,426	0.00	30%
325188	All other basic inorganic chemical manufacturing	0.0000	8,762	0.00	5%
483000	Water transportation	0.0000	1,122	0.00	3%
511200	Software publishers	0.0000	58,473	0.00	2%
334413	Semiconductor and related device manufacturing	0.0000	5,581	0.00	2%
518200	Data processing, hosting, and related services	0.0000	27,342	0.00	2%
811200	Electronic and precision equipment repair and maintenance	0.0000	36,245	0.00	2%
335999	All other miscellaneous electrical equipment and component manufacturing	0.0000	7,246	0.00	1%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	0.0000	4,122	0.00	1%
	Other product categories	0.0000	103,970	0.00	14%
TOTALS:		**0.0001**	**$568,284**	**0.00**	**100%**

Department of Geography Life Cycle Impact Assessment - Human Health Non Carcinogen					
IO Code	IO Code Description	Impact Subtotals (CTUHnoncan)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	0.0032	89,995	0.00	36%
334220	Broadcast and wireless communications equipment	0.0028	225,426	0.00	32%
325188	All other basic inorganic chemical manufacturing	0.0006	8,762	0.00	6%
334413	Semiconductor and related device manufacturing	0.0002	5,581	0.00	3%
511200	Software publishers	0.0002	58,473	0.00	2%
335999	All other miscellaneous electrical equipment and component manufacturing	0.0002	7,246	0.00	2%
811200	Electronic and precision equipment repair and maintenance	0.0002	36,245	0.00	2%
518200	Data processing, hosting, and related services	0.0001	27,342	0.00	2%
334290	Other communications equipment manufacturing	0.0001	10,646	0.00	1%
325181	Alkalies and chlorine manufacturing	0.0001	533	0.00	1%
	Other product categories	0.0011	98,036	0.00	12%
TOTALS:		**0.0087**	**$568,284**	**0.00**	**100%**

Department of Geography Life Cycle Impact Assessment - Land Use					
IO Code	IO Code Description	Impact Subtotals (Acres)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	15.0	89,995	0.00	44%
334220	Broadcast and wireless communications equipment	8.2	225,426	0.00	24%
518200	Data processing, hosting, and related services	2.1	27,342	0.00	6%
511200	Software publishers	1.2	58,473	0.00	3%
511120	Periodical publishers	0.5	5,983	0.00	1%
5111A0	Directory, mailing list, and other publishers	0.5	5,940	0.00	1%
811200	Electronic and precision equipment repair and maintenance	0.5	36,245	0.00	1%
337920	Blind and shade manufacturing	0.4	2,637	0.00	1%
334290	Other communications equipment manufacturing	0.4	10,646	0.00	1%
334413	Semiconductor and related device manufacturing	0.4	5,581	0.00	1%
	Other product categories	4.7	100,018	0.00	14%
TOTALS:		**33.8**	**568,284**	**0.00**	**100%**

Department of Geography Life Cycle Impact Assessment - Ozone Depletion Air					
IO Code	**IO Code Description**	**Impact Subtotals (kg CFC-11 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334220	Broadcast and wireless communications equipment	0.14	225,426	0.00	29%
334111	Electronic computer manufacturing	0.13	89,995	0.00	28%
325188	All other basic inorganic chemical manufacturing	0.11	8,762	0.00	22%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	0.01	4,122	0.00	3%
334413	Semiconductor and related device manufacturing	0.01	5,581	0.00	3%
3259A0	All other chemical product and preparation manufacturing	0.01	2,729	0.00	1%
511200	Software publishers	0.01	58,473	0.00	1%
334290	Other communications equipment manufacturing	0.00	10,646	0.00	1%
811200	Electronic and precision equipment repair and maintenance	0.00	36,245	0.00	1%
337920	Blind and shade manufacturing	0.00	2,637	0.00	1%
	Other product categories	0	123,669	0.00	10%
TOTALS:		**0**	**568,284**	**0.00**	**100%**

Department of Geography Life Cycle Impact Assessment - Primary Energy Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (thousand BTU)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	1164969	89,995	12.94	39%
334220	Broadcast and wireless communications equipment	864443	225,426	3.83	29%
511200	Software publishers	114999	58,473	1.97	4%
492000	Couriers and messengers	105519	4,630	22.79	4%
325188	All other basic inorganic chemical manufacturing	79763	8,762	9.10	3%
518200	Data processing, hosting, and related services	71864	27,342	2.63	2%
811200	Electronic and precision equipment repair and maintenance	71353	36,245	1.97	2%
334413	Semiconductor and related device manufacturing	46673	5,581	8.36	2%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	38824	4,122	9.42	1%
334290	Other communications equipment manufacturing	38150	10,646	3.58	1%
	Other product categories	375930	97,063	3.87	13%
TOTALS:		**2972486**	**568,284**	**3.87**	**100%**

Department of Geography Life Cycle Impact Assessment - Primary Energy Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (thousand BTU)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	1164969	89,995	12.94	39%
334220	Broadcast and wireless communications equipment	864443	225,426	3.83	29%
511200	Software publishers	114999	58,473	1.97	4%
492000	Couriers and messengers	105519	4,630	22.79	4%
325188	All other basic inorganic chemical manufacturing	79763	8,762	9.10	3%
518200	Data processing, hosting, and related services	71864	27,342	2.63	2%
811200	Electronic and precision equipment repair and maintenance	71353	36,245	1.97	2%
334413	Semiconductor and related device manufacturing	46673	5,581	8.36	2%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	38824	4,122	9.42	1%
334290	Other communications equipment manufacturing	38150	10,646	3.58	1%
	Other product categories	375930	97,063	3.87	13%
TOTALS:		**2972486**	**568,284**	**3.87**	**100%**

Department of Geography Life Cycle Impact Assessment - Water Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (kg)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	7352400	89,995	81.70	43%
334220	Broadcast and wireless communications equipment	5618328	225,426	24.92	33%
511200	Software publishers	473936	58,473	8.11	3%
325188	All other basic inorganic chemical manufacturing	416706	8,762	47.56	2%
811200	Electronic and precision equipment repair and maintenance	330877	36,245	9.13	2%
518200	Data processing, hosting, and related services	295620	27,342	10.81	2%
334413	Semiconductor and related device manufacturing	280113	5,581	50.19	2%
334290	Other communications equipment manufacturing	224930	10,646	21.13	1%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	171359	4,122	41.57	1%
334112	Computer storage device manufacturing	160237	5,692	28.15	1%
	Other product categories	1762601	96,001	18.36	10%
TOTALS:		**17,087,106**	**$568,284**	**18.36**	**100%**

Bren School of Environmental Science & Management

BREN School Life Cycle Impact Assessment - Acidification					
IO Code	IO Code Description	Impact Subtotals (H+ moles eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	24095	$84,548	0.28	75%
811300	Commercial and industrial machinery and equipment repair and maintenance	1797	$43,286	0.04	6%
325910	Printing ink manufacturing	1554	$5,840	0.27	5%
322230	Stationery product manufacturing	1003	$4,420	0.23	3%
322120	Paper mills	700	$1,386	0.50	2%
813B00	Civic, social, professional, and similar organizations	512	$6,950	0.07	2%
516110	Internet Publishing and Broadcasting	490	$7,490	0.07	2%
339111	Laboratory apparatus and furniture manufacturing	434	$6,684	0.06	1%
334300	Audio and video equipment manufacturing	345	$1,960	0.18	1%
335999	All other miscellaneous electrical equipment and component manufacturing	191	$1,115	0.17	1%
	Other product categories	1120	$11,474	0.10	3%
TOTALS:		**32239**	**$175,152**	**0.18**	**100%**

BREN School Life Cycle Impact Assessment - Ecotoxicity					
IO Code	IO Code Description	Impact Subtotals (CTUE)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	13215	$84,548	0.16	64%
811300	Commercial and industrial machinery and equipment repair and maintenance	1727	$43,286	0.04	8%
322230	Stationery product manufacturing	837	$4,420	0.19	4%
813B00	Civic, social, professional, and similar organizations	789	$6,950	0.11	4%
562000	Waste management and remediation services	748	$144	5.19	4%
325910	Printing ink manufacturing	584	$5,840	0.10	3%
516110	Internet Publishing and Broadcasting	508	$7,490	0.07	2%
339111	Laboratory apparatus and furniture manufacturing	504	$6,684	0.08	2%
322120	Paper mills	483	$1,386	0.35	2%
334300	Audio and video equipment manufacturing	426	$1,960	0.22	2%
	Other product categories	819	$12,445	0.07	4%
TOTALS:		**20639**	**$175,152**	**0.12**	**100%**

BREN School Life Cycle Impact Assessment - Eutrophication					
IO Code	**IO Code Description**	**Impact Subtotals (kg N eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	11.33	$84,548	0.00	75%
811300	Commercial and industrial machinery and equipment repair and maintenance	0.79	$43,286	0.00	5%
325910	Printing ink manufacturing	0.64	$5,840	0.00	4%
322230	Stationery product manufacturing	0.51	$4,420	0.00	3%
322120	Paper mills	0.32	$1,386	0.00	2%
516110	Internet Publishing and Broadcasting	0.24	$7,490	0.00	2%
813B00	Civic, social, professional, and similar organizations	0.24	$6,950	0.00	2%
339111	Laboratory apparatus and furniture manufacturing	0.24	$6,684	0.00	2%
334300	Audio and video equipment manufacturing	0.18	$1,960	0.00	1%
33411A	Computer terminals and other computer peripheral equipment manufacturing	0.08	$1,241	0.00	1%
	Other product categories	1	$11,348	0.00	3%
TOTALS:		**15**	**$175,152**	**0.00**	**100%**

BREN School Life Cycle Impact Assessment - Global Warming Potential					
IO Code	**IO Code Description**	**Impact Subtotals (kg CO2 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	93562	$84,548	1.11	76%
811300	Commercial and industrial machinery and equipment repair and maintenance	7960	$43,286	0.18	6%
325910	Printing ink manufacturing	5519	$5,840	0.95	4%
322230	Stationery product manufacturing	2727	$4,420	0.62	2%
813B00	Civic, social, professional, and similar organizations	2064	$6,950	0.30	2%
339111	Laboratory apparatus and furniture manufacturing	1846	$6,684	0.28	1%
516110	Internet Publishing and Broadcasting	1792	$7,490	0.24	1%
322120	Paper mills	1630	$1,386	1.18	1%
334300	Audio and video equipment manufacturing	1472	$1,960	0.75	1%
33411A	Computer terminals and other computer peripheral equipment manufacturing	720	$1,241	0.58	1%
	Other product categories	3884	$11,348	0.34	3%
TOTALS:		**123177**	**$175,152**	**0.70**	**100%**

BREN School Life Cycle Impact Assessment -Human Health Criteria Air Pollution					
IO Code	IO Code Description	Impact Subtotals (kg PM10 eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	59.85	$84,548	0.00	71%
811300	Commercial and industrial machinery and equipment repair and maintenance	4.55	$43,286	0.00	5%
325910	Printing ink manufacturing	4.25	$5,840	0.00	5%
322230	Stationery product manufacturing	3.31	$4,420	0.00	4%
322120	Paper mills	2.31	$1,386	0.00	3%
339111	Laboratory apparatus and furniture manufacturing	1.68	$6,684	0.00	2%
516110	Internet Publishing and Broadcasting	1.65	$7,490	0.00	2%
813B00	Civic, social, professional, and similar organizations	1.39	$6,950	0.00	2%
334300	Audio and video equipment manufacturing	1.13	$1,960	0.00	1%
32222B	All other paper bag and coated and treated paper manufacturing	0.51	$659	0.00	1%
	Other product categories	3	$11,930	0.00	4%
TOTALS:		**84**	**$175,152**	**0.00**	**100%**

BREN School Life Cycle Impact Assessment - Human Health Carcinogen					
IO Code	IO Code Description	Impact Subtotals (CTUHcan)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	0.0000	$84,548	0.00	73%
811300	Commercial and industrial machinery and equipment repair and maintenance	0.0000	$43,286	0.00	5%
325910	Printing ink manufacturing	0.0000	$5,840	0.00	4%
322230	Stationery product manufacturing	0.0000	$4,420	0.00	3%
322120	Paper mills	0.0000	$1,386	0.00	2%
339111	Laboratory apparatus and furniture manufacturing	0.0000	$6,684	0.00	2%
516110	Internet Publishing and Broadcasting	0.0000	$7,490	0.00	2%
813B00	Civic, social, professional, and similar organizations	0.0000	$6,950	0.00	1%
334300	Audio and video equipment manufacturing	0.0000	$1,960	0.00	1%
335110	Electric lamp bulb and part manufacturing	0.0000	$700	0.00	1%
	Other product categories	0.0000	$11,889	0.00	5%
TOTALS:		**0.0001**	**$175,152**	**0.00**	**100%**

BREN School Life Cycle Impact Assessment - Human Health Carcinogen					
IO Code	**IO Code Description**	**Impact Subtotals (CTUHcan)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	0.0000	$84,548	0.00	73%
811300	Commercial and industrial machinery and equipment repair and maintenance	0.0000	$43,286	0.00	5%
325910	Printing ink manufacturing	0.0000	$5,840	0.00	4%
322230	Stationery product manufacturing	0.0000	$4,420	0.00	3%
322120	Paper mills	0.0000	$1,386	0.00	2%
339111	Laboratory apparatus and furniture manufacturing	0.0000	$6,684	0.00	2%
516110	Internet Publishing and Broadcasting	0.0000	$7,490	0.00	2%
813B00	Civic, social, professional, and similar organizations	0.0000	$6,950	0.00	1%
334300	Audio and video equipment manufacturing	0.0000	$1,960	0.00	1%
335110	Electric lamp bulb and part manufacturing	0.0000	$700	0.00	1%
	Other product categories	0.0000	$11,889	0.00	5%
TOTALS:		**0.0001**	**$175,152**	**0.00**	**100%**

BREN School Life Cycle Impact Assessment - Human Health Non Carcinogen					
IO Code	**IO Code Description**	**Impact Subtotals (CTUHnoncan)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	0.0030	$84,548	0.00	74%
811300	Commercial and industrial machinery and equipment repair and maintenance	0.0002	$43,286	0.00	6%
325910	Printing ink manufacturing	0.0002	$5,840	0.00	4%
322230	Stationery product manufacturing	0.0001	$4,420	0.00	2%
322120	Paper mills	0.0001	$1,386	0.00	2%
813B00	Civic, social, professional, and similar organizations	0.0001	$6,950	0.00	2%
516110	Internet Publishing and Broadcasting	0.0001	$7,490	0.00	1%
339111	Laboratory apparatus and furniture manufacturing	0.0001	$6,684	0.00	1%
334300	Audio and video equipment manufacturing	0.0001	$1,960	0.00	1%
335999	All other miscellaneous electrical equipment and component manufacturing	0.0000	$1,115	0.00	1%
	Other product categories	0.0002	$11,474	0.00	6%
TOTALS:		**0.0040**	**$175,152**	**0.00**	**100%**

BREN School Life Cycle Impact Assessment - Land Use					
IO Code	IO Code Description	Impact Subtotals (Acres)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	14.07	$84,548	0.00	58%
322230	Stationery product manufacturing	2.93	$4,420	0.00	12%
322120	Paper mills	2.41	$1,386	0.00	10%
339111	Laboratory apparatus and furniture manufacturing	1.21	$6,684	0.00	5%
811300	Commercial and industrial machinery and equipment repair and maintenance	0.69	$43,286	0.00	3%
321999	All other miscellaneous wood product manufacturing	0.65	$157	0.00	3%
516110	Internet Publishing and Broadcasting	0.54	$7,490	0.00	2%
813B00	Civic, social, professional, and similar organizations	0.35	$6,950	0.00	1%
32222B	All other paper bag and coated and treated paper manufacturing	0.34	$659	0.00	1%
334300	Audio and video equipment manufacturing	0.28	$1,960	0.00	1%
	Other product categories	0.78	$17,612	0.00	3%
TOTALS:		**24.26**	**$175,152**	**0.00**	**100%**

BREN School Life Cycle Impact Assessment - Ozone Depletion Air					
IO Code	IO Code Description	Impact Subtotals (kg CFC-11 eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	0.126	$84,548	0.00	72%
325910	Printing ink manufacturing	0.013	$5,840	0.00	8%
339111	Laboratory apparatus and furniture manufacturing	0.008	$6,684	0.00	4%
811300	Commercial and industrial machinery and equipment repair and maintenance	0.007	$43,286	0.00	4%
322230	Stationery product manufacturing	0.005	$4,420	0.00	3%
322120	Paper mills	0.003	$1,386	0.00	2%
334300	Audio and video equipment manufacturing	0.003	$1,960	0.00	2%
516110	Internet Publishing and Broadcasting	0.003	$7,490	0.00	2%
813B00	Civic, social, professional, and similar organizations	0.001	$6,950	0.00	1%
32222B	All other paper bag and coated and treated paper manufacturing	0.001	$659	0.00	1%
	Other product categories	0.005	$11,930	0.00	3%
TOTALS:		**0.176**	**$175,152**	**0.00**	**100%**

BREN School Life Cycle Impact Assessment - Primary Energy Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (thousand BTU)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	1094465	$84,548	12.94	69%
325910	Printing ink manufacturing	167592	$5,840	28.70	11%
811300	Commercial and industrial machinery and equipment repair and maintenance	92490	$43,286	2.14	6%
322230	Stationery product manufacturing	32642	$4,420	7.39	2%
813B00	Civic, social, professional, and similar organizations	31418	$6,950	4.52	2%
492000	Couriers and messengers	29443	$1,292	22.79	2%
516110	Internet Publishing and Broadcasting	29386	$7,490	3.92	2%
339111	Laboratory apparatus and furniture manufacturing	20575	$6,684	3.08	1%
322120	Paper mills	19533	$1,386	14.09	1%
334300	Audio and video equipment manufacturing	14227	$1,960	7.26	1%
	Other product categories	47781	$11,297	4.23	3%
TOTALS:		**1579551**	**$175,152**	**9.02**	**100%**

BREN School Life Cycle Impact Assessment - Smog Air					
IO Code	**IO Code Description**	**Impact Subtotals (kg O3 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
334111	Electronic computer manufacturing	6171	$84,548	0.07	75%
811300	Commercial and industrial machinery and equipment repair and maintenance	423	$43,286	0.01	5%
325910	Printing ink manufacturing	365	$5,840	0.06	4%
322230	Stationery product manufacturing	267	$4,420	0.06	3%
322120	Paper mills	166	$1,386	0.12	2%
516110	Internet Publishing and Broadcasting	131	$7,490	0.02	2%
339111	Laboratory apparatus and furniture manufacturing	124	$6,684	0.02	2%
813B00	Civic, social, professional, and similar organizations	115	$6,950	0.02	1%
334300	Audio and video equipment manufacturing	96	$1,960	0.05	1%
33411A	Computer terminals and other computer peripheral equipment manufacturing	46	$1,241	0.04	1%
	Other product categories	278	$11,348	0.02	3%
TOTALS:		**8183**	**$175,152**	**0.05**	**100%**

BREN School Life Cycle Impact Assessment - Water Consumption					
IO Code	IO Code Description	Impact Subtotals (kg)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
334111	Electronic computer manufacturing	6907433	$84,548	81.70	80%
811300	Commercial and industrial machinery and equipment repair and maintenance	510430	$43,286	11.79	6%
325910	Printing ink manufacturing	178594	$5,840	30.58	2%
813B00	Civic, social, professional, and similar organizations	174915	$6,950	25.17	2%
322230	Stationery product manufacturing	157009	$4,420	35.52	2%
339111	Laboratory apparatus and furniture manufacturing	125093	$6,684	18.72	1%
516110	Internet Publishing and Broadcasting	104183	$7,490	13.91	1%
322120	Paper mills	84696	$1,386	61.10	1%
334300	Audio and video equipment manufacturing	83586	$1,960	42.65	1%
33411A	Computer terminals and other computer peripheral equipment manufacturing	45867	$1,241	36.96	1%
	Other product categories	219043	$11,348	19.30	3%
TOTALS:		**8590849**	**$175,152**	**49.05**	**100%**

Central Stores

Central Stores Life Cycle Impact Assessment - Acidification					
IO Code	IO Code Description	Impact Subtotals (H+ moles eq)	2011-12 Expenditures	Impact per Dollar	Percentage of Total Impact
322291	Sanitary paper product manufacturing	101,583	$261,172	0.39	40%
322120	Paper mills	94,596	$187,354	0.50	37%
325610	Soap and cleaning compound manufacturing	14,774	$99,068	0.15	6%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	8,028	$40,360	0.20	3%
3259A0	All other chemical product and preparation manufacturing	7,097	$28,351	0.25	3%
322230	Stationery product manufacturing	7,011	$30,907	0.23	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	3,970	$28,305	0.14	2%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	2,723	$13,488	0.20	1%
325220	Artificial and synthetic fibers and filaments manufacturing	2,186	$4,712	0.46	1%
32619A	Other plastics product manufacturing	2,169	$11,704	0.19	1%
	Other product categories	9,889	$51,615	0.19	4%
TOTALS:		**254,028**	**$757,035**	**0.34**	**100%**

Central Stores Life Cycle Impact Assessment - Ecotoxicity					
IO Code	**IO Code Description**	**Impact Subtotals (CTUE)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	86,265	$261,172	0.33	29%
322120	Paper mills	65,218	$187,354	0.35	22%
325220	Artificial and synthetic fibers and filaments manufacturing	65,058	$4,712	13.81	22%
325610	Soap and cleaning compound manufacturing	15,979	$99,068	0.16	5%
339994	Broom, brush, and mop manufacturing	11,079	$6,154	1.80	4%
313100	Fiber, yarn, and thread mills	7,613	$231	32.98	3%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	7,093	$40,360	0.18	2%
3259A0	All other chemical product and preparation manufacturing	6,006	$28,351	0.21	2%
322230	Stationery product manufacturing	5,856	$30,907	0.19	2%
315900	Apparel accessories and other apparel manufacturing	4,560	$1,315	3.47	2%
	Other product categories	18,973	$97,413	0.19	6%
TOTALS:		**293,699**	**$757,035**	**0.39**	**100%**

Central Stores Life Cycle Impact Assessment - Eutrophication					
IO Code	**IO Code Description**	**Impact Subtotals (kg N eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	48	$261,172	0.00	39%
322120	Paper mills	44	$187,354	0.00	36%
325610	Soap and cleaning compound manufacturing	8	$99,068	0.00	7%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	4	$40,360	0.00	3%
322230	Stationery product manufacturing	4	$30,907	0.00	3%
3259A0	All other chemical product and preparation manufacturing	3	$28,351	0.00	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	2	$28,305	0.00	2%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	1	$13,488	0.00	1%
325220	Artificial and synthetic fibers and filaments manufacturing	1	$4,712	0.00	1%
32619A	Other plastics product manufacturing	1	$11,704	0.00	1%
	Other product categories	5	$51,615	0.00	4%
TOTALS:		**122**	**$757,035**	**0.00**	**100%**

Central Stores Life Cycle Impact Assessment - Global Warming Potential					
IO Code	**IO Code Description**	**Impact Subtotals (kg CO2 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	235,808	$261,172	0.90	35%
322120	Paper mills	220,280	$187,354	1.18	32%
325610	Soap and cleaning compound manufacturing	63,641	$99,068	0.64	9%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	37,883	$40,360	0.94	6%
3259A0	All other chemical product and preparation manufacturing	21,791	$28,351	0.77	3%
322230	Stationery product manufacturing	19,073	$30,907	0.62	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	16,421	$28,305	0.58	2%
32619A	Other plastics product manufacturing	9,649	$11,704	0.82	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	8,638	$13,488	0.64	1%
325220	Artificial and synthetic fibers and filaments manufacturing	7,511	$4,712	1.59	1%
	Other product categories	38,205	$51,615	0.74	6%
TOTALS:		**678,900**	**$757,035**	**0.90**	**100%**

Central StoresLife Cycle Impact Assessment -Human Health Criteria Air Pollution					
IO Code	**IO Code Description**	**Impact Subtotals (kg PM10 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	327	$261,172	0.00	39%
322120	Paper mills	312	$187,354	0.00	37%
325610	Soap and cleaning compound manufacturing	60	$99,068	0.00	7%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	25	$40,360	0.00	3%
322230	Stationery product manufacturing	23	$30,907	0.00	3%
3259A0	All other chemical product and preparation manufacturing	22	$28,351	0.00	3%
325220	Artificial and synthetic fibers and filaments manufacturing	12	$4,712	0.00	1%
33411A	Computer terminals and other computer peripheral equipment manufacturing	11	$28,305	0.00	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	9	$13,488	0.00	1%
32619A	Other plastics product manufacturing	7	$11,704	0.00	1%
	Other product categories	34	$51,615	0.00	4%
TOTALS:		**842**	**$757,035**	**0.00**	**100%**

Central Stores Life Cycle Impact Assessment - Human Health Carcinogen					
IO Code	**IO Code Description**	**Impact Subtotals (CTUHcan)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	0.0002	$261,172	0.00	39%
322120	Paper mills	0.0002	$187,354	0.00	37%
325610	Soap and cleaning compound manufacturing	0.0000	$99,068	0.00	7%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	0.0000	$40,360	0.00	3%
322230	Stationery product manufacturing	0.0000	$30,907	0.00	3%
3259A0	All other chemical product and preparation manufacturing	0.0000	$28,351	0.00	2%
33411A	Computer terminals and other computer peripheral equipment manufacturing	0.0000	$28,305	0.00	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	0.0000	$13,488	0.00	1%
32619A	Other plastics product manufacturing	0.0000	$11,704	0.00	1%
325220	Artificial and synthetic fibers and filaments manufacturing	0.0000	$4,712	0.00	1%
	Other product categories	0.0000	$51,615	0.00	4%
TOTALS:		**0.0006**	**$757,035**	**0.00**	**100%**

Central Stores Life Cycle Impact Assessment - Human Health Non Carcinogen					
IO Code	**IO Code Description**	**Impact Subtotals (CTUHnoncan)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	0.0093	$261,172	0.00	37%
322120	Paper mills	0.0092	$187,354	0.00	36%
325610	Soap and cleaning compound manufacturing	0.0022	$99,068	0.00	8%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	0.0008	$40,360	0.00	3%
3259A0	All other chemical product and preparation manufacturing	0.0008	$28,351	0.00	3%
322230	Stationery product manufacturing	0.0006	$30,907	0.00	2%
33411A	Computer terminals and other computer peripheral equipment manufacturing	0.0005	$28,305	0.00	2%
325220	Artificial and synthetic fibers and filaments manufacturing	0.0004	$4,712	0.00	2%
32619A	Other plastics product manufacturing	0.0003	$11,704	0.00	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	0.0003	$13,488	0.00	1%
	Other product categories	0.0013	$51,615	0.00	5%
TOTALS:		**0.0256**	**$757,035**	**0.00**	**100%**

Central Stores Life Cycle Impact Assessment - Land Use					
IO Code	**IO Code Description**	**Impact Subtotals (Acres)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322120	Paper mills	325	$187,354	0.00	48%
322291	Sanitary paper product manufacturing	284	$261,172	0.00	42%
322230	Stationery product manufacturing	20	$30,907	0.00	3%
325610	Soap and cleaning compound manufacturing	10	$99,068	0.00	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	6	$13,488	0.00	1%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	3	$40,360	0.00	1%
33411A	Computer terminals and other computer peripheral equipment manufacturing	3	$28,305	0.00	0%
339940	Office supplies (except paper) manufacturing	3	$10,517	0.00	0%
322130	Paperboard Mills	3	$1,036	0.00	0%
3259A0	All other chemical product and preparation manufacturing	2	$28,351	0.00	0%
	Other product categories	12	$56,478	0.00	2%
TOTALS:		**672**	**$757,035**	**0.00**	**100%**

Central Stores Life Cycle Impact Assessment - Ozone Depletion Air					
IO Code	**IO Code Description**	**Impact Subtotals (kg CFC-11 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	0.53	$261,172	0.00	31%
322120	Paper mills	0.47	$187,354	0.00	28%
325610	Soap and cleaning compound manufacturing	0.21	$99,068	0.00	12%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	0.13	$40,360	0.00	8%
325220	Artificial and synthetic fibers and filaments manufacturing	0.10	$4,712	0.00	6%
3259A0	All other chemical product and preparation manufacturing	0.07	$28,351	0.00	4%
322230	Stationery product manufacturing	0.03	$30,907	0.00	2%
32619A	Other plastics product manufacturing	0.03	$11,704	0.00	2%
33411A	Computer terminals and other computer peripheral equipment manufacturing	0.02	$28,305	0.00	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	0.02	$13,488	0.00	1%
	Other product categories	0.09	$51,615	0.00	5%
TOTALS:		**1.70**	**$757,035**	**0.00**	**100%**

Central Stores Life Cycle Impact Assessment - Primary Energy Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (thousand BTU)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	2,820,315	$261,172	10.80	35%
322120	Paper mills	2,640,158	$187,354	14.09	32%
325610	Soap and cleaning compound manufacturing	943,621	$99,068	9.52	12%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	380,102	$40,360	9.42	5%
3259A0	All other chemical product and preparation manufacturing	238,090	$28,351	8.40	3%
322230	Stationery product manufacturing	228,262	$30,907	7.39	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	204,325	$28,305	7.22	3%
32619A	Other plastics product manufacturing	111,324	$11,704	9.51	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	101,580	$13,488	7.53	1%
325220	Artificial and synthetic fibers and filaments manufacturing	72,713	$4,712	15.43	1%
	Other product categories	403,873	$51,615	7.82	5%
TOTALS:		**8,144,363**	**$757,035**	**10.76**	**100%**

Central Stores Life Cycle Impact Assessment - Smog Air					
IO Code	**IO Code Description**	**Impact Subtotals (kg O3 eq)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	24,674	$261,172	0.09	39%
322120	Paper mills	22,419	$187,354	0.12	36%
325610	Soap and cleaning compound manufacturing	4,092	$99,068	0.04	7%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	2,312	$40,360	0.06	4%
322230	Stationery product manufacturing	1,869	$30,907	0.06	3%
3259A0	All other chemical product and preparation manufacturing	1,627	$28,351	0.06	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	1,046	$28,305	0.04	2%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	778	$13,488	0.06	1%
32619A	Other plastics product manufacturing	624	$11,704	0.05	1%
325220	Artificial and synthetic fibers and filaments manufacturing	533	$4,712	0.11	1%
	Other product categories	2,723	$51,615	0.05	4%
TOTALS:		**62,698**	**$757,035**	**0.08**	**100%**

Central Stores Life Cycle Impact Assessment - Water Consumption					
IO Code	**IO Code Description**	**Impact Subtotals (kg)**	**2011-12 Expenditures**	**Impact per Dollar**	**Percentage of Total Impact**
322291	Sanitary paper product manufacturing	13,034,900	$261,172	49.91	35%
322120	Paper mills	11,448,067	$187,354	61.10	31%
325610	Soap and cleaning compound manufacturing	3,195,661	$99,068	32.26	9%
326110	Plastics packaging materials and unlaminated film and sheet manufacturing	1,677,666	$40,360	41.57	5%
325220	Artificial and synthetic fibers and filaments manufacturing	1,287,774	$4,712	273.28	3%
322230	Stationery product manufacturing	1,097,950	$30,907	35.52	3%
33411A	Computer terminals and other computer peripheral equipment manufacturing	1,046,030	$28,305	36.96	3%
3259A0	All other chemical product and preparation manufacturing	989,182	$28,351	34.89	3%
32619A	Other plastics product manufacturing	493,607	$11,704	42.17	1%
32222A	Coated and laminated paper, packaging paper and plastics film manufacturing	444,854	$13,488	32.98	1%
	Other product categories	2,263,293	$51,615	43.85	6%
TOTALS:		**36,978,984**	**$757,035**	**48.85**	**100%**

Appendix 5: Survey of campus purchasers

***1. Statement of Informed Consent**

This survey is being conducted by Prof. John Melack and a group of graduate students at the University of California, Santa Barbara. The survey is part of a study regarding purchasing on campus. If you complete the survey, which should take approximately 5 minutes, you will have the choice to enter a raffle for a $50 Visa Gift Card. Your email address will be used only for the raffle and not for any identifying purposes within the study.

If you have any questions about the study, please contact:

Smart Source Team
smartsource@lists.bren.ucsb.edu

Participation in this study is entirely voluntary. You may change your mind about being in the study and quit answering the survey at any time. None of the information we collect will be used for purposes other than academic research.

If you have any questions regarding your rights and participation as a research subject, please contact the Human Subjects Committee at (805) 893-3807 or hsc@research.ucsb.edu. Or write to the University of California, Human Subjects Committee, Office of Research, Santa Barbara, CA 93106-2050.

Do you agree to these terms?

- ○ Yes
- ○ No

***5. What types of products do you purchase? (check all that apply)**

- ☐ Computers or computer accessories
- ☐ Paper products
- ☐ Batteries
- ☐ Pens, pencils, staplers, and other general office supplies
- ☐ Ink/toner
- ☐ Dining items (silverware, plates etc.)
- ☐ Larger appliances (printers, fax machines)
- ☐ Lab supplies
- ☐ Lab equipment
- ☐ Cleaning supplies
- ☐ Other (please specify)

6. For this question, define a sustainable product as having a lower environmental impact than a typical or standard product with the same function.

What proportion (by dollar amount) of the total purchases you make on campus are sustainable products?

- ○ 0-24%
- ○ 25-49%
- ○ 50-74%
- ○ 75-99%
- ○ 100%
- ○ Don't know

7. Does your department refer to sustainable purchasing guidelines?

- ○ Yes
- ○ No
- ○ Not sure

***8. Does the sustainability of a product affect your decision to buy it?**

- ○ Yes
- ○ No

*12. What percentage recycled paper content is it? (you may select more than one if you buy more than one type)

- ☐ 30%
- ☐ 50%
- ☐ 100%
- ☐ Unsure

For the following three questions, please think of the last time you chose to purchase a sustainable product

13. What product type was it?

- ○ Computers or computer accessories
- ○ Paper products
- ○ Batteries
- ○ Pens, pencils, staplers, and other general office supplies
- ○ Ink/toner
- ○ Dining items (silverware, plates etc.)
- ○ Larger appliances (printers, fax machines)
- ○ Lab supplies
- ○ Lab equipment
- ○ Cleaning supplies
- ○ Other (please specify)

14. Was this option more expensive than the non-sustainable option?

- ○ Yes
- ○ No, less expensive
- ○ No, about the same price

15. How was the quality?

- ○ Better than the average/non-sustainable product
- ○ The same as the average/non-sustainable product
- ○ Worse than the average/non-sustainable product

For the following two questions please consider the last time you chose NOT to purchase a sustainable product

16. What product type was it?

- ○ Computers or computer accessories
- ○ Paper products
- ○ Batteries
- ○ Pens, pencils, staplers, and other general office supplies
- ○ Ink/toner
- ○ Dining items (silverware, plates etc.)
- ○ Larger appliances (printers, fax machines)
- ○ Lab supplies
- ○ Lab equipment
- ○ Cleaning supplies
- ○ Other (please specify)

17. Why did you choose not to purchase the product (or the sustainable version of the product)?

- ☐ Didn't know where to find a sustainable option
- ☐ Price
- ☐ Quality
- ☐ Uncertainty about the product's performance
- ☐ Required to purchase specific (non-sustainable) product
- ☐ Prefer something else
- ☐ Don't trust environmental/sustainability labels
- ☐ Other (please specify)

***18. In general, are there specific product brand or types that you always choose?**

- ○ Yes
- ○ No

Please describe:

19. What factors do you consider when purchasing products for your department? (Please rank with one being the most important factor and 7 being the least)

- Quality
- Cost
- We always buy this product/standard choice
- Sustainability
- Convenience
- Required to use specific product
- It is the only option available

20. What do you think is the greatest opportunity to improve the sustainability of purchasing in your office?

***21. Do you know where in your building or on campus to take batteries, ink cartridges, toner cartridges and other electronic waste?**

- Yes
- No

22. Please enter your email address here if you would like to be entered for the $50 Visa gift card raffle.