UBC Social, Ecological Economic Development Studies (SEEDS) Student Report

UBC Food Systems Project: Investigating the Overall Ecological Footprint of the University of British Columbia Point Grey Campus Food System

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University of British Columbia

AGSC 450

June 2008

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The University of British Columbia Food System Project (UBCFSP)

Scenario 7: Investigating the Overall Ecological Footprint of the University of British Columbia Point Grey Campus Food System

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Abstract

The Ecological Footprint Analysis (EFA) is an increasingly popular tool to assess human demands on nature’s supply. Although this tool for footprint accounting was developed by Bill Rees at the University of British Columbia, an EFA has not been conducted for the UBC Point Grey campus. As the first university to have its own sustainability policy, UBC is constantly striving to be an eco-friendly campus. UBC’s food system plays a critical role in the sustainability on campus, as food systems are closely associated with greenhouse gas emissions. Results from a campus-wide EFA, or even an EFA of UBC’s food system alone, will be useful for future generations to monitor UBC’s progress in sustainability.

Despite the strengths of EFAs, there are also several limitations to this tool and thus EFs should be used in conjunction with other assessment techniques to assure that sustainability requirements are met. With reference to core literature, we propose a methodology for future students to follow as a guideline when conducting the EFA on UBC’s food system. This bottom-up or component approach focuses on the ecological impact of UBC’s population, using Life Cycle Analysis of a systems approach. Our recommendations consist of four steps: determine the amount of fossil fuels used; calculate the associated carbon emissions; to calculate the land needed to absorb these emissions; and compare the energy footprint to the available biocapacity.

Introduction

Over the past two decades the University of British Columbia has become increasingly aware of its impact on its surrounding environment. New steps to reduce these impacts
are in effect. Having taken initiatives such as the U-pass program and the implementation of water and energy retrofits, the University is currently examining the viability of a SUB renewal program and a Carbon Footprint Assessment, with the intention of making recommendations for a sustainable educational system. As these changes begin to shape a new campus community the need for an EFA of the increasingly large food system on campus is imperative; as the UBC food system is comprised of UBC food and beverage services and AMS food service with combined total of 35 food outlets. Although Bill Reese’s concept of ecological footprinting was developed in 1994, to date the technique has not been applied to the UBC Point Grey Vancouver Campus.

By conducting an EFA we hope to provide the University with an idea of where we stand from a global consumption perspective. We further hope this will assist the achievement of campus wide sustainability and a carbon neutral UBC. The results of a campus-wide EFA can be used as the basis for a standardized calculation template for future recommendations and sustainable business solutions on campus. UBC’s progress as a leader in climate change worldwide can be measured annually using this technique.

**Problem Definition**

**Ecological Footprint Analyses**

The Ecological Footprint Analysis (EFA) is a concept developed by William Rees to address the imbalance between human demand and natural supply (Rees, 2003). By definition, the EFA is a tool used to account for the Ecological Footprint (EF) of a specific population (Rees, 2003). The EF consists of all ecological resources needed to
support a population’s consumption, economic activity and waste production (Rees, 2003). This includes cropland, grazing land, forests, built-up areas, land for CO₂ absorption, fishing grounds, as well as fresh water and oceans (Rees, 2003). By conducting an EFA, all flows of energy and material used can be traced to their source (Rees, 2003). Examples of this include transportation, food, housing, production services and waste (Wilson & Anielski, 2005).

The EF is stated in units of “global hectares” referring to one acre of biologically productive space (Wilson & Anielski, 2005). This is an important point: different varieties of land-mass have different production capacities. The qualification for land and water areas to be deemed “biologically productive” is that they must support significant photosynthetic activity and biomass and therefore be available to humans (Kitzesm, Peller, Goldfinger, & Wackernagel, 2007). By converting the EF into measurements of global hectares, it can be directly compared natural supply (Kitzesm et al., 2007).

The EFA can be measured in a variety of ways, depending on the purpose of the analysis and the specific type of land mass (Wilson & Anielski, 2005). The most common method of analysis is to calculate carbon emissions and study the differences between carbon uptake and absorption rates (RP, 2008). This method is also known as the “absorbed carbon approach” (RP, 2008).

Before conducting an EFA, the system boundaries, land mass, and standard units must be specified (RP, 2008). After defining the population, there are four steps to calculating the EFA (RP, 2008). First the amount of fossil fuel used per year must be determined. This includes: natural gas; diesel for storage, transport and manufacturing; production and consumer consumption; and waste processing (RP, 2008). Secondly, the
figure for total fuel energy must be converted to carbon emissions (RP, 2008). Thirdly, the land area needed to absorb those carbon emissions is calculated using the carbon absorption factor (RP, 2008). Fourthly, the land area needed for carbon absorption is calculated as a carbon footprint, as compared to biological capacity if necessary (RP, 2008).

Within the four steps of EFA calculations, there are many limitations and assumptions to keep in mind. For example, a global hectare calculation can be done in several different ways; this must be standardized for accurate results. In addition, major land use is often categorized into five biological components; however, the EFA uses six which are cropland, grazing land, fishing grounds, forest, built-up area and land for CO₂ production (RP, 2008).

The EFA avoids double counting materials where possible, but it provides only a rough estimate of the true EF needed to balance production, consumption and waste processing (Rees, 2003). Under-estimations are ascribed to many factors, which include emissions from routine human activities (washing, feeding, commuting), energy emitted from buildings, wildlife contributions, carbon absorption and emissions from fields, and other food system components deemed insignificant or too difficult to define precisely.

Part of Rees’ vision in formulating the EFA was to create global, lifestyle and policy changes that would encourage more sustainable living (Rees, 2003). Since the EFA indicates the earth’s capacity to sustain the burden of current lifestyles, this information can be used to decrease vulnerability to resource scarcities and climate change (Wilson & Anielski, 2005). The EFA may be used as a planning tool to
accommodate all forms of life at the individual, metropolis, regional, national and global levels (Wilson & Anielski, 2005).

Certain assumptions must be made when calculating EFs. The majority of input resources can be traced and measured in terms of the biological productive area necessary to balance the embodied energy associated with their production. When calculating the EF of manufactured products and their derivatives, we must first convert them into their primary product equivalents in order to have a standardized land absorption unit for comparison. This is the global hectare; any global hectare in any single year is equivalent to another. Human demand can be compared to natural supply when both are equivalent in global hectares (GFN, 2007).

**Vision Statement**

After reading the vision statement developed by our project partners, our group supports and agrees with the seven principles. We came to a consensus that our views on sustainability have stemmed from our four years in the faculty and other life experiences, this perspective is reflected in the guidelines. We feel that few guidelines have been met and many have been overlooked. If UBC were to meet these guidelines, its reputation as a leader in sustainability would be strongly reinforced. However, it is disappointing to find UBC’s walk out of alignment with its thinking and talk.

We feel that there have not been enough initiatives to create environmental awareness in the whole population of the UBC campus. These guidelines can only be realized when awareness is widespread and everyone understands the actions needed to reach these goals. By establishing a fully integrated system, the University will be able to
demonstrate the effects of sustainability at all levels without restricting the transfer of knowledge to the classroom (Cortese & McDonough, 2001). From integrating education with research, external community collaborations and university community and operations, students will be provided with connections to a larger system of interactions, resulting in greater change (Cortese & McDonough, 2001).

**Methodology**

**Different models to conduct EFA**

The original methodology used by Wackernagel and Rees at UBC was the input-output model, or compound calculations through a top-down analysis approach (Ryan, 2004). This model consists of a consumption-land-use matrix composed of five major consumption categories and six major land use categories (Bicknell, 1998). Consumption categories include food, housing, transportation, consumer goods and services; land use categories include energy land, built environment, bio-productive land, sea and biodiversity land (Bicknell, 1998).

The main objective of this classic model is to account for all the land that is used during the production and maintenance of each good and service consumed by a particular community (Bicknell, 1998). National consumption and population statistics are used to estimate the average per capita annual consumption for items in each of the consumption categories (Bicknell, 1998). Many EFs exceed available biocapacities in their region (GFN, 2007). Carbon dioxide is the major waste product tracked by this model (GFN, 2007). Annual per capita consumption can be divided by the average annual productivity taken from national statistics for each item consumed to yield the
approximate area used by each person (Bicknell, 1998). Finally, the total per capita ecological footprint is obtained by adding together all ecosystem areas used for each item consumed during a specified time period (Bicknell, 1998). Since the compound approach is based on national consumption data, this technique is more appropriate for national ecological footprint analysis (Ryan, 2004).

The EcoIndex model developed by Best Food Forward uses a component or bottom-up approach depending on the data available (Chambers & Lewis, 2001). The component approach involves secondary sourced data, and the bottom up approach involves primary sourced data (Bond, 2002). This model focuses on the ecological impact of products, processes, different lifestyles, organizations and sub-national regions (Chambers, 2001). It estimates average consumption through analyzing material flows and activity components (Lewan & Simmons, 2001). Rather than obtaining data from national statistics, this model uses information from local investigations and life cycle studies (Lewan, 2001). A sensitivity analysis is also conducted with the different data sources to derive the most representative conversion factors (Chambers, 2001). Human demand is compared with the bio-capacity of the same six land categories proposed by Wackernagel and Rees in the top-down approach (Chambers, 2001). Calculations of the demand for resource production and waste assimilation are converted into global hectares by dividing the total amount by the global average yield (GFN, 2007). This area is then multiplied by the specific conversion factor to yield the total demand for each resource (GFN, 2007). The EcoIndex model is thought to be simpler and more educative since it is based on activities the population can identify and participate in, such as waste
processing (Lewan, 2001). This type of model is most suitable for UBC’s Point Grey campus.

Currently, these are the two main models available; there are many modifications of these basic models. One model, proposed by Lincoln University in New Zealand, is a modification of the input-output method; it incorporates data from regularly maintained databases that are available in most developed countries (Bicknell, 1998). This method requires the calculation of standard input-output coefficients, which are then multiplied by a land: value-of-output ratio for each industrial sector (Bicknell, 1998). The results are expressed in hectares per dollar of output, which are then multiplied by the final demand vector to determine the land required to provide for a certain level of consumption (Bicknell, 1998). This method facilitates a deeper appreciation of land requirements for industries that do not appear to be particularly land intensive (Bicknell, 1998). An advantage of this methodology is that it allows the analyst to explore the connection between international trade and the EF (Bicknell, 1998).

Additional ways to modify the current models are to view them through different lenses. The geographic lens studies the footprint of a specific geographic area, as opposed to the responsibility lens, which studies the footprint of the consumption of the population that lives within a specific geographic area (Bond, 2002).

**Partial EFA conducted at UBC and other Campuses**

A number of Universities, including UBC, have conducted partial EFAs using different methods. The following are some of the methods used.
As stated in the introduction, UBC’s whole campus has not been subjected to an EF evaluation, but at a smaller level the Pendulum Restaurant’s EF was assessed using Wackernagel’s definition of Appropriated Carrying Capacity. The Appropriate Carrying Capacity is defined as “the land… needed to exclusively produce the natural resources and services it consumes and to assimilate the waste it generates indefinitely under present management schemes. It is the land that would be required now on this planet to support the current lifestyle forever” (Wackernagel, 1994). The Pendulum’s EFA was measured using land as a biophysical measurement; everything on campus must operate within the ecological limits of the land, in addition to its own productivity and the resources consumed. Its EFA model contains five major land uses; of these, arable land, used for growing crops and animal feed, contains the greatest bio-productivity per hectare. Second is pasture, on which animals are raised for meat, hides, wool and milk. Sea land is an area from which seafood is gathered; fossil fuel land is where fossil fuels are derived; built land is land used for building. Forest and non-productive lands were omitted from the Pendulum’s EFA (Baynham & Dalton, 2005).

Williamette University is conducting an EF analysis. The electrical usage on campus is calculated by checking electricity bills for all buildings and facilities associated with the university. Water usage is determined by looking at campus water and irrigation costs. Total waste and recycling, natural gas consumption, and transportation are being explored. Most of the data collected for Willamette University is in six consumption categories: food; local food; housing; transportation; goods; and services. The data is then inserted into the compound analysis conversion system, which contains the six
consumption categories and the total acres per capita, GDP per capita and the value of land per acre is used to calculate the EF.

Concordia University examined the topic of sustainability through a framework with ten focus areas: indoor environmental and air quality; transportation, space and planning; water management; energy management; waste management; community, health and well being; purchasing materials; economy, income and investments; governance, policy and implementation; research and curriculum. Through conducting this EF, Concordia was able to make improvements through their findings on the ten focus areas and achieve a more sustainable campus (Wright, 2002).

The componential method of EFA was completed for Northeastern University (China) using energy consumption, food consumption, waste disposal, water supply, transportation and paper consumption (Li et al., 2007). Data for electricity, gas, coal, water, food and waste consumption were obtained from the logistics office of NEU; data for transportation, paper consumption and components of waste were collected via questionnaires distributed to the community.

An EFA of Colorado College used the component-based method to analyse energy and material consumption, of food, water, and manufactured goods, waste production, and the area of land occupied (Wright, E., 2002). The seven components used to measure this EFA were: electricity; natural gas; transportation fuel consumption; water; food consumption and land use. Components not calculated included pollution and waste, except for the release of carbon dioxide.

The University of Redlands also did a partial EFA calculation on their campus focusing on water, waste, energy and transportation over a time period of one year
The categories used for the study included water, solid waste, energy, and transportation (Venetoulis & Hempel, 2000) i.e. not all the components of an ecological impact study. Both Wackernagel and Richardson’s (1999) and Hempel and Venetoulis’ (1999) EFA method were used to calculate the Redlands data, a new method that provides an area-based measure that can be incorporated in to the EFA, rather than a consumption based method,

The best method for an EFA at UBC Point Grey’s Campus would be to follow a land-use consumption method rather than an area-based method or the consumption-based method. We find the land-use consumption method to be much more thorough. Using the five different land categories and the six different consumption patterns to calculate UBC’s food system’s EFA is recommended.

Baynham and Dalton’s 2005 report on the Pendulum showed that its EFA is 340 ha/yr. This is an underestimate. Many assumptions were made in the research, for example that natural resources are being managed in a sustainable fashion, leaves room for more carbon equivalents. Additionally, lack of information made it difficult to obtain data for the entire life cycle. Moreover, EFA does not directly measure the impact of our actions on the loss of biodiversity (Baynham and Dalton, 2005). The Pendulum project showed only how difficult it is to measure EFA and in turn to apply sustainability to our community.

From an analysis conducted at Newcastle University (Australia), various challenges and difficulties were encountered in conducting an EFA. The campus covers over 150 hectares of bush, wetland, creek-scapes, and build environment. In 1999, Kay Flint conducted an extensive EFA of the university to measure sustainability through a
variety of indicators. The aim was to promote management toward sustainability in the social, economic and natural environment. To measures these parameters, indicators were set up and defined to collect numerical data for comparison and analysis. It was determined that the indicators should have three functions that clearly examine quantification, simplification and communication purposes. Numerical values of human impacts on the environment \( I \) are calculated using Ehrlich & Holdren’s formulae: 

\[
I = (P \times E) + (P \times E \times N)
\]

‘\( P \)’ is the population size, ‘\( E \)’ is the energy use per capita, and ‘\( N \)’ is the extent to which energy use is non-renewable.

The project encountered some problems: there was no holistic representation of the community; there were obvious vested interests; and there was an absence of children and retirees. The most difficult factor to analyse was the human factor, since humans differ from molecules or animals in their ability to develop projects and desires. Humans also exacerbate resource scarcity through the use fossil fuel, metals, and minerals at rates vastly exceeding their natural replenishment. Categories included in the calculation were: food, building, transportation, consumer goods and services. The data was used to calculate EFA based on the following equation: expenditure x energy intensity = embodied energy. The result showed that the Newcastle’s total EF is 3592.1 Ha which represents 15% of the university’s total land area. Still, this number is an underestimate of the true impact on the university. Incomplete data meant that assumptions were made during the compilation of this survey’s results.
Findings

Policies influencing the reduction of the UBC Food System’s EF

A number of policies have been established on the international, national and UBC level that aid in the reduction of the EF of UBC’s food system. At the international level, the Talloires Declaration (TD) of 1990 was the first commitment to environmental sustainability made by university administrators; it has since been signed by over 350 post secondary establishments worldwide (ULSF, 2001). This agreement established a “ten-point action plan for incorporating sustainability and environmental literacy in teaching, research, operations and outreach at colleges and Universities” (ULSF, 2001). The action plan includes increasing awareness of environmentally sustainable development, creating an institutional culture of sustainability, educating for environmentally responsible citizenship, fostering environmental literacy, practicing institutional ecology, involving all stakeholders, collaboration for interdisciplinary approaches, enhancing capacity of primary and secondary schools, broadening service and outreach nationally and internationally and maintaining the movement (ULSF, 2001). Each university or college has adapted these points to suit their perspective.

In 1991, university presidents, government, business and NGO officials met in Halifax to discuss solutions to environmental degradation and unsustainable practices. This resulted in the Halifax Declaration. The conference targeted universities because of the influence institutions have through education, research and public service sectors (IISD, 2008). The declaration provided a unified direction which all universities involved would take through education, training, research and interdisciplinary work (IISD, 2008).
In 1997 UBC became the first campus to develop its own sustainability policy. This has had a significant effect on the campus food system. The purpose of the Sustainable Development Policy at UBC was to create an environmentally responsible campus community by making ecological, economic and social modifications for a sustainable future (UBC Sustainable Development, 2005). Such changes were to be accomplished by instilling sustainable development values in students and staff through research, teaching and operations (UBC SD, 2005).

Strategies to Reduce UBC’s EF
Currently at UBC a variety of strategies have been established to reduce the EF; many directly affect the food system. The AMS Food Service tries to purchase as much locally grown produce as possible. Some food operations purchase directly from the UBC farm. Local products such as beer are favored over imported products. In addition to an extensive recycling program, the campus composting program was developed four years ago; all restaurants use composting. Yet though student awareness of the issues is in need of improvement. Some restaurants have vegan options on their menus, and most provide recycled napkins. Many of the incandescent light bulbs on campus have been replaced with halogens.

One of the most successful projects at UBC is Ecotrek. This venture aims to reduce energy, water usage and greenhouse gas emission by rebuilding and retrofitting the infrastructure of nearly 300 academic buildings (Ecotrek, 2006). To date energy use on campus has been reduced by 20%, and water use by 30% (Ecotrek, 2006). Other goals are to reduce the consumption of electricity, steam, natural gas and water still further, and
to renew and enhance air conditioning, heating, ventilation, lighting and water-use facilities (Ecotrek, 2006). Results show that UBC had saved $3.8 million in energy costs over the last three years, and will save an additional $2.6 million annually (Ecotrek, 2006). These positive outcomes show that the Ecotrek project is effective and pioneering; UBC has met Kyoto targets to reduce greenhouse gas emissions, five years ahead of time.

Finally, paper reduction has been significant in recent years. Although there has been a surge in the student population, paper consumption has been reduced by 14% (Sustainability Office, 2008). The UPass, a reduced-fare bus pass for all UBC students, has significantly reduced GHG emissions by reducing the number of cars traveling too and from campus.

Obstacles to reducing UBC’s EF

The challenges of reducing the EF at UBC and elsewhere are intricate and complex. Perhaps the most important challenge in this area of research is to create awareness and inspire change in all people involved at the UBC Campus, including students, faculty and staff.

Methodology

UBC is continuing its efforts to find new ways to create a culture of sustainability whether through campus operations, research or teaching. A campus-wide EFA is a valuable tool to reflect the worth of these efforts. It would be useful in influencing decisions on food, housing, mobility and goods and services at UBC. An EFA can be calculated for individuals, buildings, communities or the campus as a whole. Examples of
the applicability of the EF can be found in numerous areas of activity. For example driving increases our footprints because it releases carbon dioxide; other activities such as riding a bike decreases our footprints. Increasing understanding and raising awareness about sustainability on campus through results and education is vital, and providing concrete data is imperative to providing an accurate report of the university’s current impact on natural resources. According to Redefining Progress’ latest footprint analysis, humanity is 39% over its ecological limit, meaning that we need to use more than one third of the earth’s biocapacity to maintain the global lifestyle (RP, 2008). UBC takes pride in being Canada’s first and only university to receive Green Campus Recognition in 2003, 2005 and 2006 (UBC Sustainability, 2008). Data is needed to support this recognition. We need supporting data not only to show the world that we are actually the most sustainable university but also to set an example and standard limits of sustainable consumption.

Activities that are currently excluded from EFA calculation are: the release of material for which the biosphere has no significant assimilation capacity, such as plutonion, dioxin, pollutants to name a few; tourism; and emission of greenhouse gases other than CO2 (Kitzes et al, 2007). Not all human impacts can be accurately recorded. Greenhouse gases aside from CO2 include water vapor, methane, nitrous oxide and ozone are not calculated because.

**Recommendations for an Ecological Footprint Analysis of the UBC Food System**

Globally it has been recognized that an assessment of human demand and impact on the ecosystem and environment is needed. Global warming is now a reality (Jones, 2001).
By 2050, the effects of an altered climate are predicted to be one of the top causes of species extinction (Thomas et al, as Cited in Wood, 2004). The emissions caused by human activity have been recognized internationally and nationally as an issue needing direct attention at the municipal, provincial, and federal levels of governance (Environmental Protection Act (2000). “It has been demonstrated that people are concerned about climate change and want to help emissions, but the same research indicates they do not understand the effects of their actions” (Jones, 2001). Turning remedial thoughts to effective actions is a direct challenge to our communities, corporations, and households: “The question is not whether we can act in time to stop excessive (anthropogenic) climate change, but whether we will. The evidence of history, both ancient and modern is not particularly encouraging” (Rees, 2008).

The sectoral breakdown of Canada’s GHG Emissions indicates that approximately 73% of total GHG Emissions in 2005 resulted from the combustion of fossil fuels, 7.6% from agricultural production-related fossil fuel usage (Env Canada, 2007). Furthermore, “emissions of the major greenhouse gases CO₂, CH₄, N₂O and hydrofluorcarbons (HCFCs) are closely associated with food production and consumption” (Carlson-Kanyama, 1998). In order to find sustainable solutions to the carbon equivalents created by human activity, there is a need for an analytical tool to determine concentrated areas of emissions. “The footprint's greatest strength may be in its conceptual simplicity as an indicator of sustainability. It is very clear that, if a society's footprint (appropriated bioproductivity) is larger than its available bioproductivity, it will not be able to sustain itself in the long term unless it appropriates biocapacity from others” (RP, 2008).
Analytical tools may be used as guidelines only, as there is much room for variance in data calculations. “While acknowledging the strengths of ecological footprinting, its limitations and variations in assessment methodology argue for its careful use … Thus the ecological footprint cannot be relied upon alone to confidently assure that sustainability requirements are met … Thus, ironically, while ecological footprints are used as indicators of sustainability, they fail to capture the systematic erosion of earth's carrying capacity that is the basis of sustainability” (RP, 2008). This implies that biomass equivalents calculated for the absorption of carbon equivalents are under-projected as there are sources of bio-fuels and energy that may be excluded for the purposes of simplicity in the EF’s design.

For the purpose of this study, we recommend that the groups follow Redefining Progresses LCA systems Approach method. “Not all energy sources are currently accounted for in footprint modeling. Energy footprinting typically accounts only for the major primary energy sources. Fossil fuels (coal, oil, and natural gas), hydropower, and nuclear power are handled through a direct accounting” (RP, 2008). Within these guidelines, data inputs are needed by the university’s food suppliers, food outlets, building management, and waste management teams. This is a large task and will require a focus from all participants to ensure success. We recommend that tasks be divided according to the Analysis components.

There are four main steps involved in energy footprinting. Step 1 is to determine the amount of fossil fuels used. Step 2 is to calculate the associated carbon emissions. Step 3 is to calculate the land needed to absorb these emissions. Step 4 is to compare the energy footprint to the available bio-capacity (if necessary). Before we begin this four
step process, we first must gather the data to be analyzed. To find the majority of the inputs within the different strata of the food system, we recommend that faculty members contact the suppliers of the foodstuffs delivered to UBC and create alliances to foster accurate data submission for analysis by students. For example, energy inputs of a supplier in Delta must be recorded over a standardized time interval to compare plant inputs to outputs. This may take longer than the three months allocated to group work. Teams working on the footprint model must contact suppliers and producers early in the year to ensure inputs are recorded by the participating companies. Suppliers and producers will be recognized for their efforts in contributing to a sustainable food system analysis model available to future generations of suppliers and consumers.

One task of this paper is to provide a guideline to fulfill the four steps in the analysis of the data obtained from the food system. We recommend that the final data contain a sample range and mean of possible carbon footprints. This will provide a baseline for sustainable food system recommendations based on variance found in the range of the data.

**Step 1: Calculate Energy used within the System Boundaries.**

The definition of energy used for this study includes fossil fuels (coal natural gas, oil and derivatives) hydropower, biomass, and nuclear power. Once the energy used is calculated, the associated carbon emissions can be calculated (as dictated in step 2).
Fuel amounts are stated as masses or volumes (examples include gallons of gasoline, barrels of oil, tons of coal, or cubic feet of natural gas) or by their equivalent energy contents (typically in British thermal units, therms, or joules). Carbon emissions can be calculated from fuel use data in any of these forms, assuming that the type of fuel is known and that one has a carbon emission factor for that fuel that is of the appropriate form” (RP, 2008).

**System Boundaries**

We hope to complete a life cycle analysis (LCA) of the fossil fuels created by the energy, food, materials, and waste generated within the UBC Food System and going back one layer of production. The analysis will include supply, transportation, production, consumption and waste in the system. Outside the system boundaries are the fossil fuel
inputs required for building, materials, inputs, and machine manufacturing. We have not included human labor emissions in this analysis, nor direct emissions from foodstuffs, buildings, and green space on campus. In order to standardize the input/output ratio per level in the food system, we recommend using a four week timeframe. Due to the nature of delivery and billing, this is the most suitable timeframe. The inputs needed per production level are listed as follows:

1. **Suppliers** (To be contacted in advance by the Teaching Team for monitoring availability in September 2008):
   a. Warehouse inputs (Electricity, Gas, Water or Hydro Bills, refrigeration coolants and/or HCFCs)
   b. Manufacturing Inputs (packaging, machine electricity use).
   c. Delivery quantities and transport methods and frequencies

**Assumptions, Variations and Limitations:**

a. Will not include human labor emissions or the emissions associated with human life.

b. Does not include machinery repair costs.

c. Does not include waste production from building (i.e. waste produced by employees, recycling and spoilage).

d. There will be a variance in supply numbers as not all food system components delivered to the University may be used within the selected timeframe.

e. Is limited to the economic framework provided by the supplier

2. **Transportation and Delivery data required (from suppliers):**
   a. Vehicle and fuel type (i.e. truck, boat, air, rail)
b. Distance traveled (in km)

c. Weight of goods transported (in tonnes)

_Assumptions and Variations:_

a. Distances are averages, as indicated by supplier.
b. Does not include labor, or repair costs on vehicles.
c. Transportation energy requirements will vary due to topography of the road system, daily traffic, vehicle age and make, and alternative routes used.

3. **Storage and Consumption in Retail outlet** (example: Pacific Spirit Place, Student Union Building UBC):

   a. Building inputs in meal preparation (electricity, water, oil, refrigerants).
   b. Meal preparation materials and utensils.

   _Assumptions and Variations:_

   a. Although the majority of electricity used in food service buildings is associated with the food system, there is some variation in usage. For example, buildings have multiple uses including meetings, study, and administration.
   b. Not all food materials are used within the same period as purchased (i.e. back-ordering may have occurred and there may be overlaps).

4. **Waste production on Campus**

   b. Composting inputs: Energy supplied to buildings and machinery.
   c. Garbage inputs: Energy used by buildings and machinery
Step 2: Calculate the Associated Carbon Emission Equivalents of the fossil fuel inputs in the system.

This can be done by creating an Excel spreadsheet of data inputs, and using the conversion factors based on the EPA’s Carbon Calculator in the appendices of this report. In order to calculate the associated fuel use from one unit of food transport. The following must calculated:

- the weight of all food transported to UBC within a four week time-frame.
- the distance this food has traveled from the supplier to UBC and back to the supplier.
- the amount of fuel used in this transport.
- the corresponding amount of fuel per kg food transported.

For example, if 1kg of food is transported from Delta, and the vehicle requires 10 liters of gasoline to drive to UBC and back to Delta, we can use the chart below to find that the carbon emissions associated with 1 liter of gasoline is 2.33kg/CO₂. Therefore, if 10 liters of gasoline are used in transporting 1000kg of food from the supplier to UBC, the associated emissions will be 23.30kg/CO₂.

<table>
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<tr>
<th>FUEL</th>
<th>Input Amount</th>
<th>Input Units</th>
<th>Output in lbs CO₂</th>
<th>Output in kg CO₂</th>
</tr>
</thead>
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<tr>
<td>Motor Gasoline</td>
<td>1.00 gal</td>
<td>gals</td>
<td>= 19.37</td>
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<tr>
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<td>1.00 bar</td>
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<tr>
<td></td>
<td>1.00 Li</td>
<td>ters</td>
<td>= 5.12</td>
<td>2.33</td>
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<tr>
<td>1.00 Million</td>
<td>n BTU</td>
<td>= 154.91</td>
<td>70.41</td>
<td></td>
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<tr>
<td>1.00 Giga</td>
<td>gajoule</td>
<td>= 146.83</td>
<td>66.74</td>
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</tbody>
</table>

The transportation data must be calculated separately from the building inputs as there are other factors to take into account aside from the fuel being used. The emissions
created by vehicle transport can be calculated through Stephen Bentley’s Transportation Emission Data. First we must calculate the T-km (tones per kilometer) of food transported, then multiply this number by the ‘emissions per T-km’ factor to find the emissions.

Sample Calculations:

(Emissions T-km for rail: 41; water: 30; road 207; air 1206).

Eg: (Product)(Point of origin)(Distance Travelled)(Weight)(T-km)(T-km factor)=total carbon emissions for transport.


b. Emissions from the supply buildings calculated separately. There quantities can be directly compared with the carbon emissions released by fuel consumption in the EPA’s carbon calculator.

Step 3: Calculating the Associated Biomass.

How can we balance out the equation? “Carbon sequestration footprinting calculates the biocapacity (in global hectares) needed to absorb all of the carbon dioxide emitted from fossil fuel combustion” (RP 2008). According to Redefining Progress, the simplest way of calculating the biomass needed for absorption is labeled as the ‘running footprint 2.0’. This assumes that “the entire global ecosystem (oceans and land) absorbs excess carbon at its current net uptake rate of 0.06te-C/gha/yr (0.2 te-CO2/gha/yr)”. This concludes that the global ecosystem absorbs excess carbon at a rate of 0.2 tonnes (or 200kg) of carbon dioxide per hectare per year.
For example, if 7.0 tonnes of CO2 was emitted through transportation emissions within UBC’s Food System, the associated biomass would be calculated as follows:

\[(7.0\text{tCO}_2\text{transp/year})(\text{gha-year/0.2tCO}_2) = 3.5\text{gha}\]. That means 3.5 hectares of land and sea mass is needed to absorb the transportation emissions from UBC’s food system, based on the ‘running footprint 2.0’.

**Step 4: Compare the Footprint to Available Biocapacity**

In order for the footprint calculations to be useful as a measure of sustainability, they must be compared to the local biocapacity. “To use footprints as indicators of sustainability you have to have an available biocapacity value against which to compare” (RP 2008). We recommend that groups conducting the EFA of UBC compare UBC’s population to the national population in order to determine the available biocapacity for UBC. Per capita footprints are evolving and will have changed, since the writing of this report. This method can be used to indicate UBC’s footprint based on population size and availability of data.

**Sample Calculations**

Five categories of consumption at UBC must be analyzed at multiple levels to conduct an EFA.

i. Food: produce, meats, dairy, grains.

ii. Building: maintenance costs (hydro, electric, water, heating and storage)

iii. Transport: fuel, diesel, lubricants.

iv. Consumer goods: office supplies, trays, utensils etc
v. Services: Waste, recycling, composting

To make the most accurate assessment of the entire UBC food system, it would be ideal to have data for all five categories. The extent of information available must be traceable back to one degree of production. For the purpose of this study, we will begin examining inputs at the level of supply. Starting with the quantity of food UBC receives from the suppliers, the data required is essentially an inventory indicating quantities, frequencies and where the food at UBC is sourced (i.e. which company). Next we can look at factors of the supplier’s storage facilities. The amount of energy that is required for maintenance and storage of these products, such as hydro, electricity and other building costs, contribute to the ecological footprint. Moving on to transportation of food from the supplier to UBC campus, the types of delivery trucks, type and amount of fuel used, and the distance from storage to UBC and back must be recorded. Now the food has reached UBC campus, and the amount of energy used at UBC to prepare these foods must be analyzed in the footprint. Finally, energy required for disposing of remaining waste whether by recycling, composting or treating as garbage must be included.

Not all of this information will be readily available. Building maintenance information from the suppliers is not normally kept to hand. Information on the delivery trucks may also be difficult to acquire depending on how willing the companies are to release such figures (which they were not at the time of this writing). Once this data is gathered, groups may check the company’s website for its location and use the information to calculate carbon emissions from the delivery trucks using estimates based on existing transportation emission data. The energy inputs for food preparation at UBC may be difficult to acquire. Data will not be stored in the same file. The rate of
consumption may vary throughout the year. UBC waste management does not currently maintain records of their energy inputs. They may be able to supply an annual report from which the required data may be extracted as a figure within a range rather than a specific number.

Contacts such as Dorothy Yip and Nancy Toogood may be willing to be interviewed to provide information as they worked closely with the AGSC 450 teaching team. All data not included in the final footprint calculations must be referenced in the assumptions and limitations section of the final report prepared by 2009’s AGSC450 groups. We recommend the final EFA numbers be presented as a range of data including a mean.

A sample of final data in the transportation section might look like: The t-Co2 associated with transportation within UBC’s food system is between 2.5-3.5t-Co2 with an average of 2.7t-C02 emitted per year. Thus, x global hectares are necessary in order for UBC to maintain its current transportation usage for the food system.

**Conclusion**

EFAs have been conducted in many places ranging from whole countries to small restaurants. The EF has become a globally recognized indicator of sustainability. However, as a leader of sustainability, UBC has only had partial EFAs conducted on its campus. Partial EFAs significantly underestimate the true EF of an area. In order for future generations to examine the impacts of UBC’s current sustainability initiatives, numerical data, like an EF of the Point Grey campus, need to be established. Examining the campus food system, which strongly influences the campus sustainability, is a good
Studying the numerous models of EFA available, the bottom up or component approach appears to be the most suitable for conducting an EFA on UBC’s food system. This methodology involves four main steps. These steps are first, to determine the amount of fossil fuel used per year; second, to calculate the associated carbon emissions per year; third, to calculate the land area needed to absorb those carbon emissions; and lastly, to compare the energy footprint to the available biocapacity if appropriate.

We recommend the teaching team contact suppliers, supplier transport companies, UBC food outlets and Waste management with a formal request for their enterprise budgets. These can be analyzed by AGSC 450 groups to extract the embodied energy inputs needed for calculating the EFA. The group must decide on system boundaries of the project and consider the feasibility of their goals with respect to resource and time constraints.
References


Reese, Bill. Personal Presentation to AGSC450 Class. February 27, 2008.
“2015 is the last year in which ‘the world can afford a net rise in GHG emissions, after which ‘very sharp reductions’ are required’ (IPCC Chairman, Sept 2007).”


# Carbon Emissions Calculator

<table>
<thead>
<tr>
<th>FUEL</th>
<th>INPUT amount</th>
<th>INPUT units</th>
<th>OUTPUT in Pounds CO2</th>
<th>OUTPUT in kg-CO2</th>
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<td>Motor Gasoline</td>
<td>1.00</td>
<td>gallons</td>
<td>19.37</td>
<td>8.80</td>
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<tr>
<td></td>
<td>1.00</td>
<td>barrels</td>
<td>813.54</td>
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<tr>
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<td>1.00</td>
<td>liters</td>
<td>5.12</td>
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DATA SOURCE: www.epa.gov/appdstar/pdf/brochure.pdf

(*) 1 short ton = 2000 lbs