Ecofootprinting the Pendulum Restaurant

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"Every organism, be it a bacterium, whale or person, has an impact on the earth. We all rely upon the products and services of nature, both to supply us with raw materials and to assimilate our wastes."[1]

The interconnectedness of both our global ecosystem and globalizing economy are becoming increasingly apparent. The extent of human impact has reached virtually every corner of the earth; there is essentially no land that humankind has not touched or transformed. Likewise, there are very few aspects within our daily lives that do not depend upon this very land and the resources that it provides.

Currently, the value our society places on our resources is expressed solely through prices. The benefit that nature provides is externalized and the true cost of producing goods is in fact much higher than the market value.[2] This model seems to be derived from the "mistaken belief that society and the environment exist to serve the economy rather than the other way around."[3] In the long term, our economy and society can continue to thrive only within an environment that is balanced and healthy. We must find a tool to assess our use of natural resources if we are to work towards a system of resource use that can be continued into the future.

Economic and social institutions, such as businesses and universities, have a responsibility to lead a positive example in their use of natural resources. Thus, the purpose of this report is to measure and quantify the environmental impacts of the Pendulum Restaurant in the University of British Columbia's Student Union Building (SUB) by calculating the ecological footprint, in order to assist the Alma Mater Society (AMS) in continually exploring more sustainability initiatives and to educate students about the importance of their role in the global ecological system.

Driven by the speculation in today's world concerning our present consumption levels and the sustainability of our economic activities, the Ecological Footprint has been developed to answer the question: how much nature do we have versus how much are we using? Eco-footprinting is strongly

[1] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; xiii.
[2] Ragan, C., Lipsey, R. Macroeconomics. Toronto: Pearson Education Canada Inc, 2005; 512.
[3] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 5.

based upon the concept of carrying capacity, an idea that is widely accepted and used by biologists.[4]

Carrying capacity describes the population of a given species that can be supported indefinitely by a defined area or habitat. As Chambers, Simmons and Wackernagel explain, in order to be supported indefinitely, the species must not be consuming the resources faster than they can be generated. Once a population is harvesting nature's capital stock rather than living on nature's annual interest, the population is overshooting the carrying capacity. Ultimately, this results in a draw-down of natural resources to the point where the community can no longer survive as it has in the past. Although it is possible for a population to continue expansion once it has overshot capacity, the growth will be unsupported. There have been numerous accounts of species that have had sudden population crashes on account of over-consuming the very resources that sustain them. Humans, although we have the benefit of modifying our own environment to suit our needs, and can thereby increase our surroundings' carrying capacity, are by no means exempt from this phenomenon. In fact, Easter Island once supported an advanced and complex society of approximately 4000 people and was covered in fertile, forested soils. Their overuse of the land eventually led to limited amounts of food, triggering extreme conflict among the people, and inevitably a complete population crash. Today, there are no inhabitants on the island.[5]

That is not to say that the human race is doomed to collapse. Although it may be argued that it was human's intellect that got us into this predicament, it can be equally argued that with a little foresight, we are fully capable of getting ourselves out. There is much speculation about the world's carrying capacity for humans, and whether we have yet to overshoot it. An enormous range of figures have been suggested for earth's human carrying capacity, and the variance can be attributed to different assumptions on what we eat, people's expectations for health and living standards, and how much land we should delegate for other species' survival. The most common estimate is 5.5 billion, which we have already exceeded, and the median of all estimates is 9.5 billion, which we will have reached by 2050.[6]

Accepting that we have already or are soon to be reaching the upper population limit our earth

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[4] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 46.
[5] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 46-51.

can support, brings us to the question: Which of our activities contribute the most to this over-use of resources and how do we measure their impacts? Ecological carrying capacity is limited here, as it tells us only about the supply of nature, and says nothing about human's demand on nature. It also ignores *how* resources are being used up and the extent that resources are used for certain defined activities. Knowledge of ecological carrying capacity enables us to identify the problem, but does not suggest a means for alleviating that problem, and so is not motivational. Eco-footprinting on the other hand, measures the land area a population demands according to its present consumption. By breaking consumption down into different activities and putting a number on the resources used, we are able to compare this with the land actually available and gauge where our lifestyles are no longer sustainable. It then becomes possible to make decisions that will have a large impact on the amount of resources we use, and we can make substantial strides towards sustainability.

The Ecological Footprint, also known as the Appropriated Carrying Capacity, as defined by Wackernagel is "the land which is 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."[7]

The ecological footprint has numerous benefits, the first being its use of land as a biophysical measurement. As Wackernagel asserts, unlike the use of prices to determine worth, a land measurement respects that we must operate within ecological limits since land itself is finite and is the limiting factor on nature's productivity. Moreover, it is applicable to every lifestyle and human action since all activities require land to produce the resources and absorb the wastes. Secondly, expressing the eco-footprint in land area units makes the data accessible since an area such as hectares or square kilometres is a value that anyone can comprehend. Thirdly, an ecological footprint can be applied independently of geographic scale. It is possible to measure the eco-footprint of a single child, a household, a business or an entire country. In addition, the eco-footprint accounts for *global* consumption which is especially important in

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6 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 49-52.
7 Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward

today's world since we are no longer drawing down resources only in our immediate area, but internationally. Thus, it becomes easy to link elements of the global sustainability crisis to our own actions on a local level. Lastly, by its very nature and for reasons will be described in more detail further on, the eco-footprint is an underestimation of the true resource requirement. Although this implicitly means that there is a loss of accuracy, it also means that as a tool, it can be more widely accepted with the knowledge that the data it provides is not the least bit exaggerated. As a decision-making tool, it is a relatively simple model and allows for impact assessment of alternative practices so that a thorough cost-benefit analysis can be done, and tradeoffs measured.[8] In order to use this tool effectively, it is important to distinguish the different types of productive land on earth, as well as the variety of ways we consume resources.

LAND USE CATEGORIES

Different divisions of land types and bio-productivity

The majority of the Earth's surface area is water. In fact, of the 51 billion hectares of surface area on this planet, less than 15 billion hectares is land. To get a better idea of the land that is available to us, Chambers, *et al.* divide the global land resources into five categories: built up land takes up 2 per cent of the earth's total land area, forest and woodland is 33 per cent, pasture land is 23 per cent, arable land is 10 per cent, and other land (which includes ice, rocks, desert, etc.) represents 32 per cent.[9]

The total land area which has been altered by human activity can be estimated by adding the total amount of arable, pasture and built land, and is currently about 35 per cent of the global land area. In the next fifty years this figure is expected to rise significantly, as we continue to convert the remaining natural areas to land used for human production.[10]

Land that can potentially be used by humans to produce goods is termed bio-productive land. The

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sustainability." Diss. UBC, 1994; 68.

[8] Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward sustainability." Diss. UBC, 1994; 67-69, 97.

[9] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 36-37.

total amount of bio-productive land has been estimated at somewhere between 8.7 and 10.3 billion hectares. The latter estimate, a more optimistic approximation and the figure used by Chambers, *et al.* will also be applied in this report.

Land use categories used in our study

Arable Land is defined as "land under temporary or permanent crops, which covers everything from rice to rubber production - although it excludes land used to grow trees for fuel wood or timber".[11] Arable land is used mostly for staple crops such as grains, tubers and pulses. It can grow the largest amount of plant biomass, and therefore is considered, biologically, to be the most productive land.[12]

Pasture land is used primarily for raising cattle and occasionally other grazing animals, with the most common food products being beef and dairy. It generally refers to land that has been used for raising animals and that is either natural pasture land or converted.[13]

Sea space productivity is fairly complex to calculate. This is because, as Chambers, *et al.* point out, there are more levels to the aquatic food chain than the terrestrial food chain, so the total energy that goes toward feeding a fish is much larger. Seafood yields (per hectare of ocean) are therefore much lower than land-based biomass production. However, seafood consumption is counted in terms of the equivalent area of land required to produce the same amount of meat (in calories), rather than the physical area of the sea which is required.[14]

Fossil energy land is the area required to act as a sink for the products of fossil fuel combustion. This land is therefore necessary in order to keep ecological balances intact and allow for the long-term sustainability of an activity. Although in a sense this land is "invisible" because only a very small area is specifically used for the production and processing of energy resources, its footprint can add up to be quite significant due to the amount of energy used and the large amount of land required to sequester

[10] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 37.
[11] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 37.
[12] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 61.
[13] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 37.
[14] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 62.

carbon dioxide produced.[15]

Built land has not been included in our calculations in the consideration that the Student Union Building and other buildings which play a role in the ecofootprint of the Pendulum are already existing structures (economically and ecologically, a sunk cost) and are not adding to the ecofootprint on a yearly basis. Forest and non-productive lands have also been omitted since the Pendulum's activities have a minimal or nonexistent impact on them.

Importance of distinguishing land types

It is necessary, when studying an ecological footprint, to take into account the type of land that is being used for production. Bio-productivity of land varies depending on its land use patterns; for example, pasture land is typically less productive than arable land by a factor of ten. This can be explained by the lack of efficient energy conversions from plant to animal, meaning that we will receive only 10 per cent of energy from animal-sourced foods as we do from an equal weight of plant-sourced foods.[16]

Different authors use varying approaches to the division of land use categories when accounting for ecological footprints. For example, Chambers, *et al*. incorporate bio-productive sea space into footprinting calculations, whereas the Krause Calculator that was provided by Dr. Bass at the University of Toronto, includes land but not water productivity.

Human use of global land (and water) resources

Clearly, the different land classifications presented above are not geographically proportionate throughout the world. Chambers, *et al*. point out the fact that only 18 per cent of Asia's total land area is forested, whereas South America has nearly 3 times as much of its landmass covered in forests, or about 53 per cent.[17] Through the globalization of our economy, a country's consumption patterns are no longer solely dependent on its own resources. Since the top five traded commodities are cereals, sugar, coffee,

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15 Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward sustainability." Diss. UBC, 1994; 104-109.
16 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 62.
17 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 38.

cocoa and bananas, it is apparent that international trade is particularly important when addressing issues of food production and consumption. International trade has allowed a number of countries to rely on the food production and land use in other countries for the majority of food that they consume. The dependent countries are generally high income, densely-populated or have few natural resources. The Lower Fraser Valley of BC, for instance, is home to 1,700,000 people and is a land area of more 4000 square kilometres, averaging a population density of 4.25 people per hectare. According to average Canadian consumption and land productivity, the average person in the Lower Fraser Valley uses 18 times more land than is available within the region for food production, forestry products and energy.[18] This production of food must therefore take place outside of the region and food must be transported in. This leads to the concept of "importing land," which allows a country to consume more than is available within their boundaries for production.[19]

The health and sustainability of seemingly distant ecosystems becomes increasingly important to our society as we realize the extent of our interdependence within the global economy, and many Canadians are becoming concerned about environmental degradation throughout the world. Chambers *et al.* identify the three main causes of "human-induced land degradation" as overgrazing, deforestation and agricultural mismanagement.[20]

Biological diversity is greatly affected by environmental degradation, primarily due to loss of habitat. According to Chambers *et al.,* studies have shown that the annual species loss is at least 1000 times the rate of extinction from natural causes.[21] There are many ecological and ethical reasons for the importance of biodiversity. In a human-centered viewpoint, the most compelling argument for securing biodiversity is to ensure the long-term availability of our renewable resources for human consumption. The World Commission on Environment and Development stated that at least 12 per cent of the world's ecosystems need to be preserved in order to safeguard ecological stability, and many ecologists argue that

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18 Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward sustainability." Diss. UBC, 1994; 124.

19 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 37-39.

20 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 38.

more than that is necessary. Using a conservative 12 per cent for the land required to sustain biodiversity, Chambers *et al.* have declared that at our present world population each human must learn to live within a footprint of around 2 hectares. This is known as the average per capita earth share.[22]

Use of average productivities

Global averages of land productivities must be used when applying land area as a standardized measurement unit and converting consumption levels into land-use. This is important given that most urban communities rely on the global production of goods and thus are using land located in other regions. Moreover, it allows for an accurate comparison of land-use between countries and regions since the same values will be used for calculations, in addition to the fact that computation is made easier. This also avoids the total footprints of different land categories from being skewed. Consider for example, a local piece of agricultural land that is twice as productive as the world average; that is to say, twice as many crops (by weight) are produced from this land than are produced on the "average" piece of land. By using a global average value for this doubly productive local region, means that the local land counts for double its area. If the region were to be paved over, it would mean a loss of ecological productivity that is twice as large as well. Since some regions in the world will be below the global average productivity, adding up each regionally-adjusted area will be equivalent to the productive land area that is available on the planet.[23]

CONSUMPTION CATEGORIES

Our ecological footprinting approach is a component-based calculation which separates consumption into a series of categories. Average footprint values for certain activities are pre-determined and can be used to calculate the eco-footprints within each component or category. As opposed to using a resource-flow calculation, a component-based approach allows for easily communicated data, and can

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21 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 44.

22 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 65-66.

23 Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward sustainability." Diss. UBC, 1994; 112-113.

facilitate straightforward and transparent decision-making processes. It is effective for monitoring the effect of people's behavioural changes and is simple to apply to any scale. Its major limitations are inconsistencies between footprint values from various data sources, and its inability to adjust to changes in technology, since this would require a revision of the footprinting value.[24] Consumption is generally divided into six main groupings for ease of data collection, interpretation and decision-making:

a) food
b) consumer goods
c) services
d) transportation
e) housing/facility
f) materials and waste

Each category can then be subdivided, depending on what the exact assessment entails. This section outlines which categories are included in the data collected for this report, as well as how each calculation is derived. Assumptions for each category are described in Tables 4.1, 4.2, and 4.3 within the section entitled: Steps to Gathering Data and Sample Calculations.

a) Food

In order to assess the Pendulum restaurant, food was subdivided as much as possible into categories such as fruits, vegetables, pork, beef, poultry, etc. Processing, transportation, agricultural and embodied energies are all included in the footprinting figure for food production, using average global yields where appropriate. Interestingly, it often takes more energy to grow, harvest, process and transport the food than is actually contained in the food itself![25] The transportation energy embodied in food production is minimal and presumably only accounts for transport within the production chain, from the farm to the processing plant to local stores, and any other stops along the way. It was assumed that it does not account for the long distances that food is moved in Canada. The section entitled transportation explains in more detail how the eco-footprint of fossil energy is derived.

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[24] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 67-74.
[25] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 87-89.

b) Consumer Goods

Supplies that the restaurant orders on a monthly basis were recorded within the consumer goods category. However, the eco-footprints of these provisions (stir sticks, plastic cups, napkins, etc) were not calculated so as to avoid double counting land that is accounted for in materials and waste.

c) Services

Services were not included in the calculation of the Pendulum's footprint, but can include such categories as education, health care, and social services.

d) Transportation

Transportation was an important contributor to the eco-footprint, since a large amount of food comes from international locations. The footprint for fossil energy, the fuel that drives our economy, can be calculated in several different manners as outlined by Wackernagel, each producing roughly equal values. The first approach is to calculate the land requirement for growing the ethanol equivalent of the given fossil fuel consumption. Another method requires an assessment of the land needed to restore the natural capital stock at the same rate that it is being consumed. The last method provides the most conservative estimate and is most widely accepted and used. It is the approach that is used in this assessment, and involves determining the land area required to sequester CO_2 from fossil fuel combustion. This assumes that the addition of CO_2 into the atmosphere is undesirable and has an overall negative impact on humanity. This assumption stands strong given that our planet that may have to deal with significant climate change in the near future, due to greenhouse gases such as carbon dioxide. Average forests can absorb approximately 1.8 tonnes of carbon per hectare per year which is roughly equivalent to the consumption of 100 Gj of fossil fuel, and takes account of the CO_2 released during oil extraction and refinement.[26]

For transportation of food to the Pendulum restaurant, subdivisions included transport truck, train and ship. The truck was assumed to be a heavy goods vehicle and includes the embodied energy that

[26] Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward sustainability." Diss. UBC, 1994; 104-109.

went into building both the vehicle itself and the proportioned area of the road network used during shipments of commodities to the restaurant. The estimate for diesel freight train integrates fuel, manufacture and maintenance energy as well as apportioned space for the rail network. The energy footprint for ships is that of a coaster's manufacturing and maintenance energy, as well as fuel usage. All figures are based on EU data and are assumed to be analogous to numbers for Canadian transportation. More personal footprinting projects can incorporate categories such as bus, bike, and car.[27]

e) Facility

The facility was subdivided into energy and water consumption. Energy used at the Pendulum restaurant was exclusively hydroelectric. The land-use figure for hydro is derived from the amount of land used for power lines and flooding as well as the embodied fossil fuel energy required to build and maintain the dam. Water was calculated strictly from the use of the dishwasher, and includes the embodied energy of supplying the water. Heating of the water is included in the hydroelectric energy that is required to run the appliance, and so was not calculated on its own to avoid double counting.

f) Materials and Waste

This section includes both the embodied energy in the production of certain core materials such as timber, cotton, glass and aluminum, and the land required to absorb the disposal of such materials. Care must be taken not to double count the production of materials from other sections such as consumer goods when calculating this footprint. Most items have the ability to be either recycled or landfilled and different figures are available to calculate either of these footprints. Generally, the recycling value is derived from the amount of energy that would be saved from producing the item from recycled as opposed to virgin materials.[28]

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27 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 82-87.
28 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 90-96.

STEPS TO GATHERING DATA AND SAMPLE CALCULATIONS

Production of Food and Consumer Goods

The AMS Food and Beverage Services provided transfer sheets for the Pendulum Restaurant, which included the total inventory of products and the number of units ordered per month for each product during a four-month period from September to December 2004.

In order to find the total mass (in kg) of each food product that was used per year, the mass of one unit had to be determined. This was not always specified on the transfer sheets, so it was sometimes necessary to find food products in the storage room and weigh them per unit. Once the per-unit mass was found, it was multiplied by the number of units of that food product for the total four-month period and divided by four to find a monthly average. A yearly average mass (in kg) for each food product was found by multiplying the monthly average by twelve.

Sample Calculation:

Dark Roast Organic Fair Trade Coffee: According to Pendulum Transfers, each unit is equal to a 5 lb bag.

- Convert to kilograms: 5 lbs * 0.453592 kg / lb = 2.267962 kg / unit
- Total number of units ordered from Sept. to Dec.: 8 + 7 + 6 + 4 = 25 units/four months = 6.25 units/month.
- Total mass (in kg) per year: 2.26796 kg/unit * 6.25 units/month * 12 months/year = 170.1 kg/year

After the total mass per year for each food product was calculated, that item was placed into its appropriate food category and land use was analyzed for each of the four land types: fossil energy, arable land, pasture land and sea.

There were two tools available for use in calculating footprints for the different categories of food and consumer goods production. The first is the Krause calculator, which allows a person to input the mass of a food item or consumer good into a spread sheet, and automatically receive a corresponding footprint value. The second is a series of specific "footprint multipliers" for each food category, which can be multiplied with the mass of the food item to find the total footprint (in hectares) of that specific food item for each land type (i.e. fossil energy, arable, pasture, sea). These multipliers were obtained using data from Table 11.2 in Sharing Nature's Interest,[29] and an overview of the assumptions are outlined in Tables 4.1, 4.2, and 4.3 below. The Krause calculator, however, does not have any background information available on the assumptions made for its calculations, and is therefore used only as a secondary method for interpreting data, not as a primary method of calculation.

Table 11.2 in Sharing Nature's Interest expresses the amount of each type of land (in m^2) used for a particular mass of food in each category.[30] For the purpose of this study, the amount of land was divided by the mass (in kg) to obtain a simple footprint multiplier, which is the equivalent amount of land used to produce one kilogram of food. Items ordered for the Pendulum in small quantities were assumed to be negligible and excluded. If an item had a large number of ingredients and was not specified in Sharing Nature's Interest, it was calculated using only the primary ingredient, such as finding the footprint for tomatoes to represent tomato sauce. Beef used in the Pendulum was assumed to be grain fed as opposed to pasture fed. Beer, bottled water and Coke, were assumed to have the same footprint value as juice and wine.

Sample Calculation:

From Table 11.2 (Chambers *et al.* 2000, p. 169): Food Category: Tea and Coffee:

- Fossil energy: 90 m^2 / 12 kg = 7.50 m^2 / kg * 170.1 kg coffee = 1275.750 m^2
- Arable land: 212 m^2 / 12 kg = 17.67 m^2 / kg * 170.1 kg coffee = 3005.667 m^2

The total amount of land in each food category was then converted to hectares using a conversion factor of 1 square metre = 0.0001 hectares.

Sample Calculation:

- Fossil energy: 1275.750 m^2 * 0.0001 = 0.128 hectares of fossil energy land
- Arable land: 3005.667 m^2 * 0.0001 = 0.301 hectares of arable land

29 Chambers, Nicky, et al. Sharing Nature’s Interest. London: Earthscan Publications, 2000; 169.
30 Chambers, Nicky, et al. Sharing Nature’s Interest. London: Earthscan Publications, 2000; 169.

Table 4.1: Footprint Multiplier (m² of land used per kg of food) for each Food Category and Land Type[31]

Category	**Fossil Energy (m²)**	**Arable Land (m²)**	**Pasture Land (m²)**	**Sea (m²)**	**Assumptions**
Fruit, vegetables	0.50	0.56	-	-	-average global yields used -calculated for the whole group, not specific crops -transport, processing and agricultural energy included
Bread	2.00	2.36	-	-	-average global yields used -transport, processing and agricultural energy included
Rice, cereal, noodles	1.00	3.65	-	-	-same as above
Beans	1.00	11.73	-	-	-same as above
Milk, yogurt	1.00	-	19.92	-	-average global yields used -transport, processing and agricultural energy included -cattle raised on pasture land
Cheese, butter, cream	6.50	-	199.19	-	-same as above
Eggs (50 g each)	6.50	0.64	-	-	-average global yields used -transport, processing and agricultural energy included
Pork	8.00	21.83	-	-	-same as above
Poultry	8.00	12.75	-	-	-same as above
Beef	8.00	58.33	-	-	-average global yields used -transport, processing and agricultural energy included -cattle are grain fed
Fish	10.00	-	-	551.75	-average global yields used -transport, processing and agricultural energy included -pelagic (wild, not farmed) fish
Juice and wine	0.42	1.00	-	-	-average global yields used -transport, processing and agricultural energy included
Sugar	1.58	2.08	-	-	-same as above
Oil and fat - solid	3.92	5.42	-	-	-same as above
Oil and fat - liquid	3.08	4.33	-	-	-same as above
Tea and coffee	7.50	17.67	-	-	-same as above

[31] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 169.

Transportation

Locations of food production and processing were determined by contacting the restaurant suppliers, speaking with representatives responsible for purchasing food through the AMS, and by reading information from food labels. Food that was produced within North America was generally assumed to be transported by standard freight truck. The exceptions to this were products shipped through the port of Montréal and wheat that came from the Canadian prairies, both of which were assumed to be transported by rail to Vancouver.

Distances transported by truck were calculated using road distances rather than geographical distance. This was calculated using the mapquest tool,[32] which calculates the shortest distance between any two points in North America using the major highways that would be used by large trucks. Shipping destinations were estimated depending on closeness of proximity and route to Vancouver or to Montréal, and were calculated using a World Atlas.

Footprint estimates for freight transport were calculated from Table 5.6 in Sharing Nature's Interest by multiplying the total mass of the product by the total distance traveled and then by its corresponding footprint multiplier, as shown in the chart below.[33]

Table 4.2: Ecological Footprint Estimates for Freight Transport

Freight	Footprint (hectare-years/1000 t-km)	Assumptions
Rail (train)	0.01	An estimate for a diesel freight train. Includes fuel, manufacture and maintenance energy plus an estimate of apportioned rail space.
Road (truck)	0.07	Heavy goods vehicle (HGV) embodied energy per t-km with a proportioned area of the road network used by freight (from EU data).
Sea (ship)	0.01	Energy footprint of a coaster – does not include any sea or land areas associated with freight movement.

[32] www.mapquest.ca. March 2005.

In this table, hectare-years are calculated per 1000 tonnes-km (t-km). In order to calculate the number of hectare-years used per kg of food for each km that it is transported, the mass of the food product was multiplied by a factor of 0.000001, since 1 ha-yr / 1000 t-km is equal to 1 ha yr / 1,000,000 kg-km.

Sample calculation:

- Sleeman beer transported by truck from Guelph, ON: 713.7 kg * 0.000001 * 4321.7 km * 0.07 (footprint multiplier for road transport) = 0.2159 ha/year
- Sleeman beer alternatively transported by train from Guelph, ON: 713.7 kg * 0.000001 * 4321.7 km * 0.01 (footprint multiplier for rail transport) = 0.0308 ha/year

<u>Facility</u>

Footprints were calculated for two facility categories: hydroelectricity and water use. Included in hydroelectricity are three subcategories: appliances, lights and heating/cooling.

The first step in finding the energy use for appliances was to determine the manufacturer company name, product name and/or number, and any other information about each appliance that was available. Most appliance manufacturer companies had a website with product information that provided the wattage of the appliance, or the amps and volts which could be multiplied to determine the number of kilowatts used per hour (kWh). If the exact model could not be found, similar models of different makes were researched and specified that the value was approximate in Table 5.3 of this report. Paula, the student manager at the restaurant, provided estimates of the number of hours per week that each appliance is used. The duty cycles for the refrigerators, the soup warmer and the oven were not included in the calculations due to difficulties in estimation. This number was then multiplied by the kWh for that particular appliance to find the total energy per week. After totaling the footprint value for the appliances per week, it was assumed that their usage would remain constant throughout the year the footprint was multiplied by 52 weeks/year.

The footprints for both appliances and lighting were calculated by using the footprint multiplier

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[33] Chambers, Nicky, et al. <u>Sharing Nature's Interest</u>. London: Earthscan Publications, 2000; 87.

for hydroelectricity in Table 5.3 of Sharing Nature's Interest.[34] The footprint can vary significantly for hydroelectricity, from 10 to 75 hectare-years per GWh, depending on the type of installation. As Chambers, *et al*. advise to do when limited information is available,[35] this study uses the middle value of 42.5 as the footprint multiplier for hydroelectricity. Since there are one million kWh in one GWh, the value must also be multiplied by a factor of 0.000001.

Sample calculation:

- Steamer: 8 kWh * 7 hours used/week * 42.5 (hydroelectricity footprint multiplier) * 0.000001 = 0.0024 hectare-weeks

There are four types of lighting used in the Pendulum restaurant: halogen spots, MR-16 Halogens, Fluorescent Tubes (T-12) with 7 ballasts and incandescent light bulbs. Total energy used for lighting was calculated by multiplying the number of each type of bulb by the number of kWh it uses followed by the number of hours the lights are on per week. All of the lighting was calculated for 85.5 hours per week. After totaling the footprint value for the lights per week, it was assumed that light-usage remains constant the entire year and the footprint was multiplied by 52 weeks/year.

Sample calculation:

- Halogen spots: 18 lights * 0.09 kWh/light * 85.5 hours/week * 42.5 (hydroelectricity footprint multiplier) * 0.000001 = 0.0058 hectare-weeks

Heating/cooling energy use was provided by Jesse Klimitz, a student at the University of Toronto, who assessed the energy performance and consumption patterns of the Pendulum Restaurant. The energy performance models were created using the Environmental Services Performance – Research (ESP-r) energy simulation software. According to Klimitz, ESP-r is an integrated modelling tool which can simulate power flows for heat, air, moisture and electricity, and assess energy use and gaseous emissions. Klimitz used blueprints, information about the building geometry and construction materials of the

[34] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 83.
[35] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 80.

restaurant, in addition to Vancouver's 1997 climatic data to create the building models. The total annual kWh used by the Pendulum for sensible heating and cooling with consideration for the use of appliances, were taken from Klimitz's report.[36]

Materials and Waste

Materials and waste includes the garbage and recycling of materials used at the Pendulum as well as the production of all materials, including those ordered by the Pendulum on a monthly basis, such as stir sticks, napkins and plastic cups.

Garbage was collected for a period of one day. During this time the restaurant was open for 12.5 hours, and the total mass of garbage produced was 30.17 kg. This was broken down to estimate that the Pendulum Restaurant produces approximately 2.4 kg of garbage per hour, and assuming that the restaurant is open 71.5 hours/week for 52 weeks, 8923.2 kg of garbage per year are produced. This estimate does not include any waste that is taken outside of the restaurant and disposed of, but may include waste that is brought in.

The components of the garbage include about 70 per cent non-recyclable plastic products and 30 per cent paper products, also mostly non-recyclable. There were relatively few recyclable items and virtually no compostables found in the garbage cans in the restaurant. It was estimated that 20 per cent of aluminum cans and 15 per cent of glass bottles eventually ended up in the landfill.

Recycled items were counted, weighed and placed in four categories: aluminum cans, regular glass (beer, juice, cider) bottles, large glass (wine) bottles and cardboard/paper materials.

For each category of garbage and recycling, the total mass per year was multiplied by a footprint multiplier for that specific material, taken directly from Table 5.9 in Sharing Nature's Interest.[37] The mid-point values were taken for each material because of insufficient information around the assumption details as well as waste and recycling processes in Vancouver.

[36] Klimitz, Jesse. "UBC Restaurant: Energy Footprint Analysis." University of Toronto; 2005.

Sample Calculation:

- Garbage - plastic: 8923.2 kg garbage / year * 0.70 = 6246.24 kg plastic / year
- Convert to tonnes: 6246.24 kg plastic / year * 0.001 = 6.24624 tonnes plastic / year
- 6.24624 tonnes plastic / year * 3.85 (footprint multiplier) = 24.1 hectare years

Table 4.3: Ecological Footprint Estimates for Various Materials and Waste

	Ranges in footprint multiplier (ha-yrs/tonne)	Footprint multiplier used in this study (ha-yrs/tonne)	Assumptions
Aluminum cans - landfilled	9.4 to 17.8	13.60	-embodied energy. mining land and landfill land included
Aluminum cans - recycled	0.4 to 0.9	0.65	-accounts for the energy saved by using recycled as opposed to primary material
Glass bottles - landfilled	1.0 to 1.1	1.05	-embodied energy of production from primary material, plus landfill land
Glass bottles - recycled	0.8 to 0.9	0.85	-accounts for the energy saved by using recycled as opposed to primary material
Plastic - landfilled	3.6 to 4.1	3.85	-embodied energy and landfill land included, based on nine different plastics
Paper - landfilled	2.8 to 4.0	3.40	-embodied energy of production from primary material, plus landfill land
Cardboard/Paper - recycled	2.0 to 2.9	2.45	-accounts for the energy saved by using recycled as opposed to primary material

[37] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 95.

RESULTS AND DISCUSSION:

The overall footprint calculated for the Pendulum Restaurant was 340 hectares per year. Assuming an average of 350 customers in the restaurant per day, there would be approximately 126,000 customers served in a year. This means that the average customer uses 0.0027 hectare-years of land each time they are served. That's about 27 square metres, or an area that is slightly larger than five metres by five metres.

The following tables show the breakdown of the total footprint and outline interesting trends and noteworthy data points:

Production Footprint (see Table 5.1)

Despite the fact that the Pendulum Restaurant uses only a small amount of seafood (tuna and salmon), the footprint of sea area used was substantial. Seafood requires a much larger area to sustain its production than land-based organisms, because there are a greater number of trophic levels through which energy must be passed before seafood can be consumed by humans. At each trophic level, only 10 per cent of energy is transferred to the next consumer. Although the Krause calculator has a high footprint value for seafood, there is still a large disparity between its value and the value calculated in Sharing Nature's Interest. These two calculation methods also differ for the land used to produce dairy, by an alarming factor of ten! It is important to take note of these possible sources of error since dairy is the single largest contributor to the Pendulum's footprint, based on the massive amounts of cheese that are used by the restaurant. The large footprint value for cheese can also be attributed to the high milk requirement for making cheese; around ten litres of milk is required to make one litre of cheese.

Despite the differences between Krause and Sharing Nature's Interest, there are many food products which have similar footprint values for both calculation methods, especially fruit, vegetables and bread. These same food products also have the smallest overall contribution to the Pendulum Footprint. Exact footprint values per kilogram of food are summarized in Table 3.1.

As previously mentioned, the footprint value for consumer goods is included in the calculation for materials and waste. However, the total mass of each consumer good was recorded for reference.

Transportation Footprint (see Table 5.2)

The main difference found in transportation was that the footprint for trucks is seven times higher than for both train and ship transport. Therefore, an item such as tuna which traveled over 13,000 km by ship from Thailand, would still have a smaller footprint than an item of the same weight, such as spaghetti, which traveled one fifth of the distance by truck from Missouri. This has important implications when unsure about the method of transport for food across large countries such as Canada. In this study, it was often difficult to get in contact with distributors to obtain information about where food products came from as well as how they were transported. As shown in the sample calculations, the difference in footprint for Sleeman beer traveling by train vs. by truck from Guelph, Ontario illustrates the effect of uncertainty in transportation methods. In fact, the footprint of Sleeman beer traveling by train is less than 15 per cent than the same quantity of beer transported by truck.

Facility Footprint (see Table 5.3)

Certain appliances were in operation for a significant amount of time, such as the refrigerators which run 24 hours per day and the grill which is on for the entire time the restaurant is open. These appliances generally have a higher footprint. Overall wattage of appliances was reasonably low, with the shocking exception of Frymaster's pasta cooker, which contributed to a substantial portion of the footprint for appliances.

The contribution of energy use for lighting, heating and cooling to the overall facility footprint was relatively small. Water use was practically inconsequential, partly because it only includes the embodied energy in supplying the water and not any of the other impacts. Moreover, the general use of water for such things as hand-washing and drinking water were not included due to the difficulty in estimating them.

Materials and Waste Footprint (see Table 5.4)

By far the largest contributor to the materials and waste footprint is plastic that ends up in the landfill, which is mostly made up of plastic bags, wrapping and cups. Unfortunately, there is no recycling option for these types of plastic, which is why it is such a large value. The other major component is paper products, and there is very little food waste thrown in the garbage. All of the food waste from kitchen preparation is composted. This has a positive contribution to the natural environment.

The processing of aluminum alone requires a lot of the world's energy; in fact, smelting comprises an astonishing one per cent of global energy use.[38] Since aluminum is so light, the impact of each can entering the landfill is underrepresented in the footprint data. Landfilled aluminum has a footprint that is about 20 times higher than recycled. Indeed, if all of the aluminum cans which ended up in the landfill were recycled instead, the footprint would be reduced by 0.8 hectares per year.

The same calculation was done for glass, and it was found that if all landfilled bottles were recycled, the footprint for glass would be reduced by 0.1 hectares per year.

LIMITATIONS AND CONCLUSION

As Wackernagel suggests, the majority of limitations show up as underestimations within the ecofootprinting assessment. The primary restriction that is imposed is due to the assumption that natural resources are managed in a sustainable fashion. This would mean that the 340 hectares of land used by the Pendulum Restaurant this year will be able to support the same level of activity in the future as it does now. Unfortunately, the bio-productivity of land throughout the world is generally decreasing due to poor management, human-induced contamination and degradation of the natural environment.[39] Moreover, although ecofootprinting acknowledges that a certain amount of land should be set aside to protect biodiversity, it doesn't directly measure the impact of our actions on the loss of biodiversity.

Chambers *et al*. explain a number of other limitations in using ecological footprint analysis.

To begin with, there is a difficulty in obtaining data for entire life cycles of goods due to a lack of information and labeling for production locations, transportation types and distances. Furthermore, data experiences diminishing accuracy because of varying assumptions and discrepancies. For example, the large variation in values for hydroelectricity results from different construction methods and materials, as

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[38] Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 92.
[39] Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward

well as the size and altitude of the dams.[40]

It is important to recognize that the Ecofootprint as a model is merely a snapshot in time. The growing population means that fewer resources will be available per person with each coming year. In other words, each individual's earthshare is effectively decreasing.[41]

The above limitations were found to be very prominent during the course of this study. In particular, a lack of available models, and other information sources made it difficult to complete the assessment with a high degree of accuracy. Furthermore, the depth and comprehensiveness of the study was limited by a lack of data for comparison of footprints, especially for food production such as organic versus non-organic methods. When assessing sustainability, social implications must also be considered, however ecofootprinting only examines the environmental component. This can be limiting since initiatives such as fair trade are not included within the ecofootprint, and so cannot be used as a tool for assessing the absolute sustainability of a system.

RECOMMENDATIONS

Ecofootprinting as an assessment tool:

Further research is needed to make the ecological footprint assessment a more accessible and effective tool. It is necessary to have clearer, more detailed assumptions so that the researcher can apply the data according to the particular project situation that is being assessed. Decision making would be easier if there were more footprinting values for alternatives such as different food production methods and methods for waste management. This would allow for decisions to be made with about the magnitude of impact that each choice would have. The option of composting for example, should be incorporated into the eco-footprint as a positive contribution to the bio-productivity of land. Most importantly, a standardized list of footprint multipliers for all categories should be compiled so that there

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sustainability." Diss. UBC, 1994; 113.

40 Chambers, Nicky, et al. Sharing Nature's Interest. London: Earthscan Publications, 2000; 83.

41 Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward sustainability." Diss. UBC, 1994; 113.

are no discrepancies between studies due to differing data sources. Also, it would make the process of footprinting much easier and more accessible to those who don't have the background in it.

Future Projects:

Extension of this project can be taken in a number of various directions. An important next step is to take this report into more detail in terms of the specific assumptions that have been used. For instance, verification should be made about where food is coming from and how it is transported. Research should include the full life cycle of more complex food items, not only the processing of primary ingredients, but also the production of input materials. More material on other footprinting projects should be explored and used for the sake of comparison.

A reassessment of the Pendulum's footprint would be valuable to do in 3-5 years from now. This would help to recognize achievements that the Pendulum is making and track their progress towards sustainability. It's important to note that some of the largest contributing factors to the restaurant's eco-footprint will be the hardest to change, such as land appropriation for food production. In the next evaluation, some categories can be assumed to be constant over time, while others will have to be entirely reassessed. This decision will be up to the discretion of the next researcher with input from the restaurant managers.

A possible project related to business and marketing is to plan a way to incorporate the results from this study into public relations at the restaurant. An example is to indicate the footprint required to produce each dish on the menu board, or to have signage at each garbage can to raise awareness about the ecological value of recycling. As well, a computer model can be developed specifically for restaurant managers in a format that allows them to measure their business footprint by answering a series of questions and inputting specific data.

Another extension of this project is to do an entire footprinting report on a similar restaurant such as 99 Chairs at UBC. This would be beneficial for comparing the environmental impacts of different methods of restaurant management.

Any or all of these projects can be integrated into the Agricultural Sciences 450 class.

Decision-making at the Pendulum:

The Pendulum has already taken many steps towards being an environmentally sustainable business. A large proportion of their food is locally grown or produced and this choice should be continued whenever possible. As a major establishment, AMS Food Services should be pushing to have suppliers provide detailed information on food production and location for each order. This will allow the restaurant to determine whether some products such as olive oil, pesto, rice and various vegetables can be purchased from closer locations. Beer is good example of a product that can be purchased locally or from far away, and so it is recommended that the restaurant offer mostly local beer, and phase out the less demanded foreign beer. The large footprint that animal products have means that increasing vegan options at the restaurant would have a positive effect.

Composting in the kitchen is another great initiative that the managers of the Pendulum have adopted. The idea of integrating this into the seating area could be a very rewarding challenge for the restaurant to take on. Fortunately, the Pendulum already uses recycled napkins, and having a compost receptacle available for them would allow for the completion of a more ecologically friendly napkin lifecycle.

As mentioned in the discussion above, footprints can be reduced considerably by recycling. Thus, a place should be made for recycling at every garbage can in the facility, with signs to promote proper disposal of containers. Furthermore, since plastic was the largest component in the footprint of materials and waste, care should be taken to ensure that none of the plastic that can be recycled ends up in the garbage.

Since water used for dishwashing has a relatively low footprint value, it is recommended that reusable cups replace the disposable ones currently available to customers for drinking water.

The majority of the Pendulum lighting is already energy efficient, but could be improved by replacing the halogen spots with MR-16 halogens and removing the incandescent lights altogether. Four incandescent light bulbs use one fifth of the energy that forty-nine MR-16 halogens use!

While most appliances are used at a reasonably energy efficient level, the Frymaster pasta cooker is an exception that needs to be looked at. The wattage for this appliance is extremely high and the staff reported that although it is usually turned on, it is only used to cook pasta a few times throughout the day. It is mostly left on for the purpose of reheated cooked pasta. Therefore, if there are other options for reheating pasta, this appliance could potentially be used much less.

By following these recommendations, the Pendulum will continue to soften the footprint that it places on the global natural environment.

Table 5.5: Consumption – Land-use Matrix for the Pendulum Resaurant

THE MATRIX	ENERGY LAND	ARABLE LAND	PASTURE LAND	SEA	Total
FOOD PRODUCTION	16.0	19.4	224.8	18.5	**279**
TRANSPORTATION					**5**
Food	4.4	-	-	-	
Consumer Goods	0.1	-	-	-	
FACILITY					**12**
Hydroelectricity					
Appliances	10.6	-	-	-	
Lights	0.9	-	-	-	
Heating/Cooling	0.8	-	-	-	
Water	negligible	-	-	-	
MATERIALS AND WASTE					**42**
Garbage	34.5	-	-	-	
Recycling	7.5	-	-	-	
Total:	**75**	**19**	**225**	**19**	**338**

BIBLIOGRAPHY

Chambers, Nicky, Simmons, Craig, Wackernagel, Mathis. Sharing Nature's Interest. London: Earthscan Publications, 2000.

Mapquest (available online). <www.mapquest.ca> March 2005.

Klimitz, Jesse. "UBC Restaurant: Energy Footprint Analysis." University of Toronto; 2005.

Ragan, Christopher T.S., Lipsey, Richard G. Macroeconomics. Toronto: Pearson Education Canada Inc, 2005

Wackernagel, Mathis. "Ecological footprint and appropriated carrying capacity: a tool for planning toward sustainability." Diss. UBC, 1994.