The Ecological Footprint of Kwantlen Polytechnic University In 2013

Source: Wackernagle, Mathis and Bill Rees, 1996. Our Eological Footprint. Gabriola: New Society

A Report by

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Note: The collaborative nature of this study
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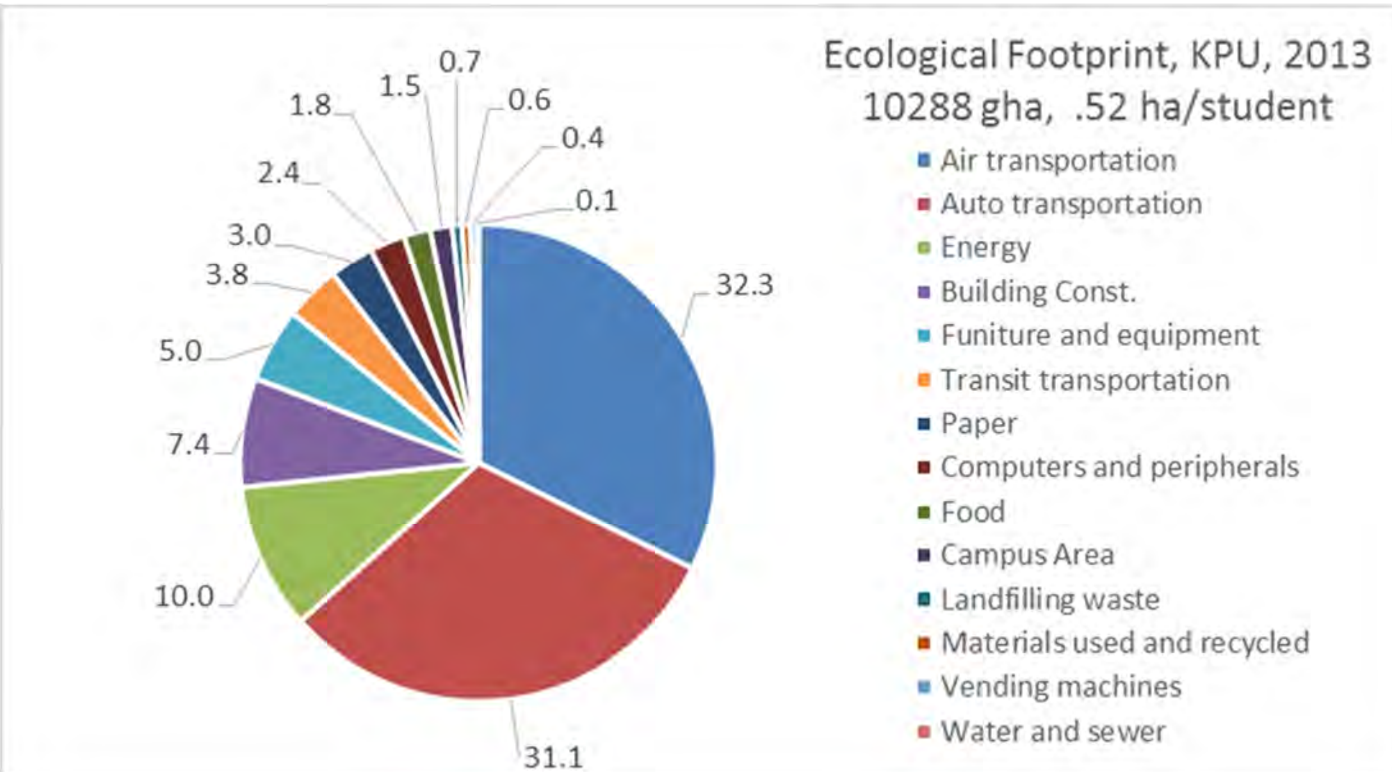
0.1 Executive Summary

The area of land required to produce the resources consumed by and to absorb the waste produced by KPU in 2013 was 9,690 global hectares, or over 150 times the 62-hectare area of KPU's four campuses.

This calculation was derived by compiling data from various administrative units of the university and then calculating the area of land or water somewhere on earth that is required to sustain the activities in question. The various methods employed for these calculations were selected to best address the available data.

The largest contributors to the KPU ecological footprint were air flights by international students and KPU staff (34%), auto transportation (25%), electricity and gas energy (11%), and a one year's share of the construction of buildings on campus (8%). Food and waste do not have large footprints in relative terms, but they are nonetheless notable because of simple ways in which their footprints can be reduced.

Figure 0: KPU Ecological Footprint, 2013



Source: See text

These footprint areas should be considered accurate to about an order of magnitude. However, at this level of precisions their calculation is still worthwhile. The main function of an ecological footprint is educational. It makes more concrete what is or is not sustainable, or what is more or less sustainable than something else. Footprint calculations can and should inform policy.

Recommendations from this study include the following:

- That the ecological footprint of KPU should be calculated annually using a comparable methodology.
- That KPU direct major efforts at reducing the need for students and staff to commute by car, notably by becoming a major public voice for better transit in the South-of-Fraser region.
- That KPU institute more separation of waste on campus and compost on campus all organic waste including food scraps.

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0.3 Table of Contents

1.0 Introduction

1.1 Sustainability – Responsibility and Opportunity for KPU

Universities are places of knowledge, wisdom, conversation, and innovation. With a total campus population of about 20,000 students, faculty and staff and its polytechnic mandate KPU can play a substantial role in promoting a more sustainable future. It can educate its own population. It can function as a model for other institutions and the community as a whole.

1.1.1 Role of Universities in Transition to Sustainability

In 1964 Professor John Diekhoff wrote, "It is not enough for the university to be ahead of the world in knowledge… it must…bring the world along" (The University as Leader and Laggard, 181). This has never been truer than with regard to sustainability.

Thousands of universities have now ratified the Talloires Declaration, the Kyoto Declaration, and the Copernicus Charter to express their commitment to furthering sustainability holistically in their institutions. An understanding of environmental issues and a moral obligation to work towards true sustainability drive these and other initiatives and agreements (Lambrechts and Van Liedekerke, 2014).

Their adoption reflects the definition of sustainable development: to provide for the means of the present without compromising the means of future generations. As a publicly funded educational institution, KPU depends on future students. The inherent intergenerational nature of universities is a profound argument for embedding sustainability in all their functions.

1.1.2 Implementing Sustainable Policies in Universities

In order for sustainability policy to be effective within a university it must be understood, developed, and implemented holistically on a systemic and cultural scale. A holistic policy would fully integrate the economic, social, and ecological considerations of all facets of the institution (Ralph and Stubbs, 2013). Many universities have voluntarily agreed to integrate sustainability into their institutions. However, sustainability policies tend to be disconnected and ineffective (Lambrechts and Van Liedkerke, 2014).

The most prominent barriers are generally internal. Public institutions face financial constraints, especially in this neo-liberal era. Strong competition for resources within such institutions tend to disfavor sustainability initiatives whose benefits are not quantifiable in the short-term and are not accounted for in traditional budget modeling (Ralph and Stubbs 2013).

A lack of understanding of the benefits of sustainable policy integration, which stems from a lack of awareness of environmental issues, is a major factor in the commitment and effectiveness of implementation from staff (Ralph and Stubbs 2013). There is also a natural resistance to change in large institutions, contributing to a difficult implementation process.

Another barrier may be a lack of consensus around the conceptualization of sustainability (Sherren et al, 2010). Finally, the sheer difficulty of developing holistic sustainability for an institution with many working parts inhibits many institutions from meaningful progress towards sustainability.

Universities can overcome these barriers by viewing sustainability policy as being embedded rather than overarching. Instead of one office imposing a singular vision of sustainability on all departments, as would be traditional practice for such a policy, universities should determine how to use pre-existing institutional infrastructure to foster inter- and transdisciplinary sustainability (Sherren et al, 2010).

This deep institutional change must involve all stakeholders and does not necessarily need to have a uniform vision. However, sustainability must be measured and detected in every discipline, operation, and goal of the institution in order to achieve true embeddedness. Committed individuals, institutional commitment, and adequate funding are all necessary to realize effective sustainability policy (Ralph and Stubbs 2013).

1.1.3 Sustainability Policy and Practice at KPU

KPU has adopted some initiatives regarding sustainability. They cannot all be reviewed but some points regarding KPU's progress are highlighted below.

1.1.3.1 Curriculum

As of 2014 there were sixteen degrees and six diploma/certificate programs that incorporate sustainability into their learning requirements (Zaidi, 2014). Several academic programs have sustainability at their core, including Policy Studies, Sustainable Agriculture, and Environmental Protection Technology. These programs embrace the interdisciplinary nature of sustainability. However, they are still in their infancy. Their success at promoting systemic changes through cross-pollination of programs and a greater awareness of the importance of sustainability is not yet clear. KPU has not yet earned the reputation of being a center for sustainability education and research.

1.1.3.2 Energy Policy

One area where Kwantlen is an established leader is reducing energy consumed by its physical plant. A variety of policies have been instituted regarding the reduction of energy consumption and carbon emissions, some pursuant to provincial legislation mandating energy conservation in the public sector.

A strategic energy management plan was implemented to address annually reported energy consumption across all four campuses. The plan uses consumption data, energy savings ideas, possible energy savings on capital renewal and maintenance, and new technology to further reduce energy consumption (Strategic Energy Management Plan, 2013).

Many actions such as light retrofitting, capital renewal projects, and new construction and renovations have been identified as important in the further reduction of energy consumption at KPU. The plan notes that educational institutions must reduce their impact on the environment and that the cost of energy will increase with time (Strategic Energy Management Plan, 2013).

A seven-year or better payback is cited as an indicator of cost-effective investment, though longer-term return may be considered if there is reduction of other costs. Multiple buildings on KPU campuses hold a Leadership in Energy and Environmental Design (LEED) certification. All new buildings and renovations at KPU are targeted to LEED standards.

1.1.3.3 Environmental Sustainability Committee

An Environmental Sustainability Committee (ESC) exists to bring together the work of different departments and provide cohesive leadership and planning of sustainability initiatives (Zaidi, 2014). The ESC meets a minimum of three times a year for one to two hours and includes students, faculty, and staff. It has produced a living document to record sustainability initiatives at KPU (Zaidi, 2014).

The ESC can serve as a uniting body for sustainability at KPU. However, it should be acknowledged that this Committee is far from the center of discussions on most University affairs. Sustainability and polytechnic are still not regularly used in the same sentence.

1.2 Concepts of Sustainability

1.2.1 'Weak vs. 'Strong' Sustainability

As noted above, one barrier to sustainability policy within a given institution may be the lack of shared understanding of this concept. Figure 1 below expresses 'strong' sustainability. It does this by containing economy and society within the biophysical environment. This acknowledges there are ecological limits to human activity, e.g., how much can be drawn from the natural world and how many natural functions can be replaced by human technology.

Strong sustainability requires "fundamental reassessment of values resulting in revamping behaviours" (Lombardi et al, 2010). It is the most challenging conception of sustainability because radical changes are required to current economic, social, and political systems to bring them in line with environmental processes.

Figure 1: 'Strong' Sustainability

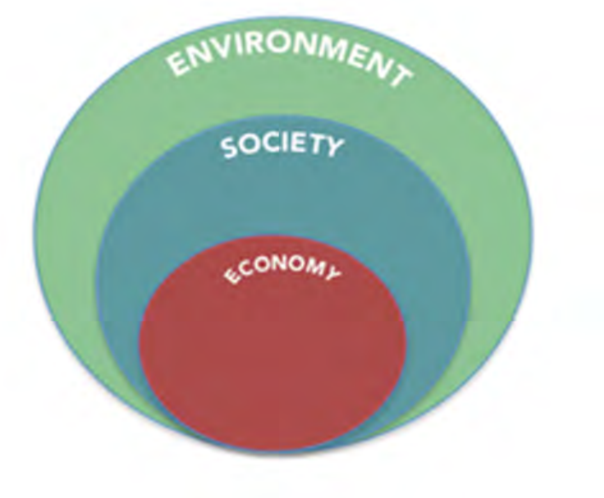
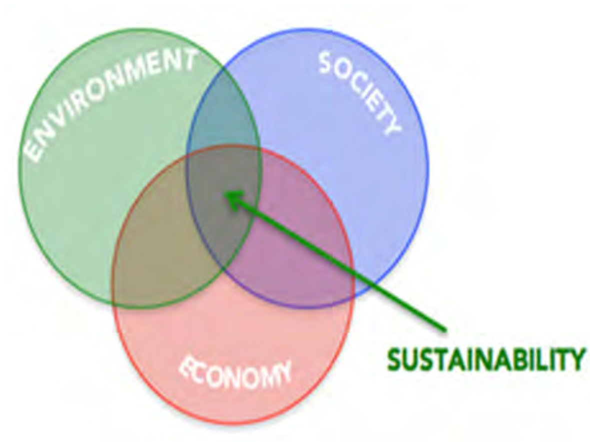


Figure 2: 'Weak' Sustainability



'Weak' sustainability is expressed by Figure 2. An extreme version is 'faux' sustainability, where the ambiguity of the term is simply exploited for other purposes (Lombardi et al, 2010). Other descriptors are 'business as usual' and 'greenwashing'.

The key assumption of weak sustainability is the existence of a 'sweet spot' where equally valid requirements of environment, society, and economy coincide. Economic and social requirements may thus 'trump' those of the environment as what is deemed 'sustainable' must also be economically profitable. This version emphasizes making 'smartest' available choices within the existing socio-economic system rather than changing that system and its relation to nature.[1]

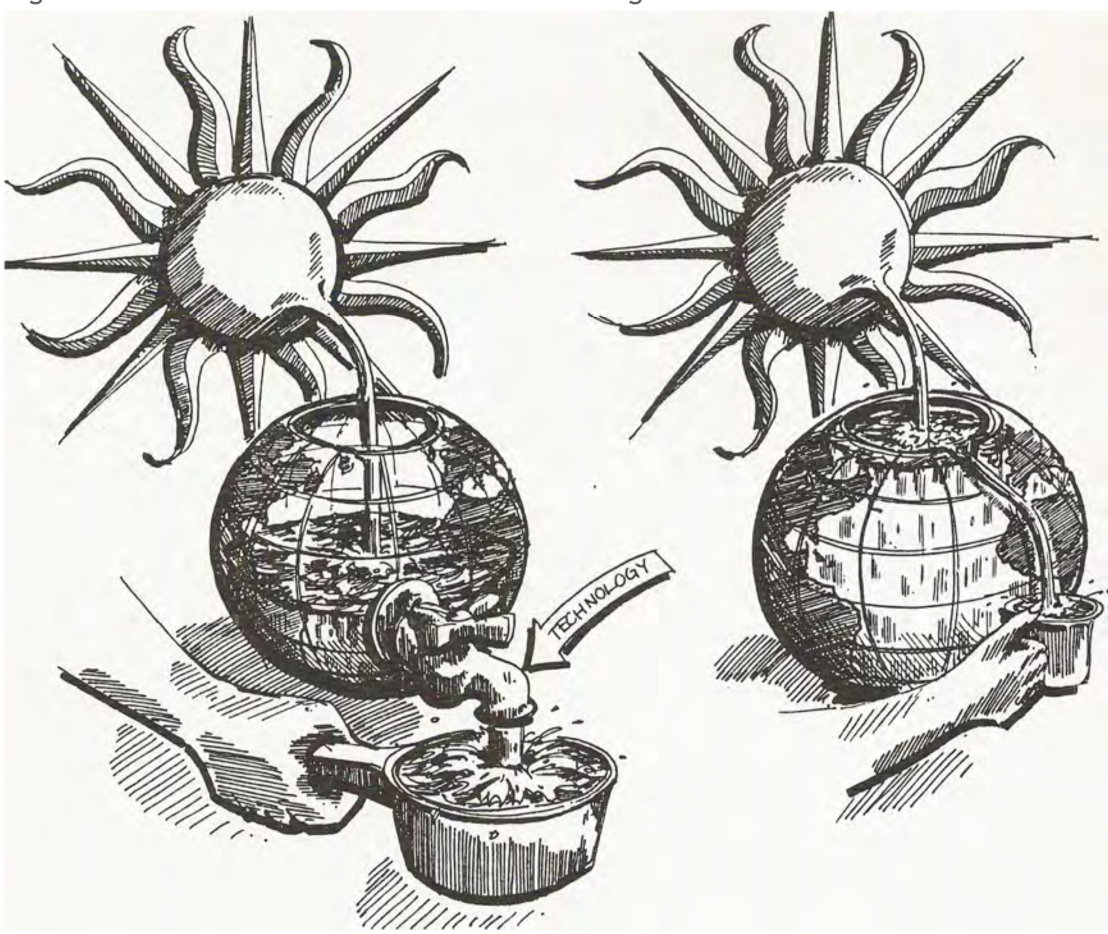
1.2.2 Which Concept for KPU Policy?

Individual opinions can and should vary, but ‘strong’ sustainability should, in principle, guide policy at KPU. There are limits to what changes KPU can make itself without the broader socio-economic changes required to this perspective to be implemented more broadly. However, we can commit to trying to lead, to raise our own bar as high as or higher than in other institutions. We can and should avoid the ‘easy’ solutions that fail to demand that we re-think…almost everything.

1.3 Ecological Footprints to Inform Sustainability

While the concept of sustainability is not difficult to grasp, how can we judge what is and is not sustainable? The ecological footprint allows such discussions to become much more concrete. It measures whether we are using essential resources produced by nature more quickly than they are renewed by natural processes (Rees and Wackernagle, 1996). The earth is basically a closed system except for the input of solar energy. Figure 3 illustrates how we are limited by this biophysical reality.

Figure 3: Not sustainable vs. sustainable: ‘Living on nature’s interest’



Source: Wackernagel and Rees, 2006

The ecological footprint is measured in terms of the area of land (and water) needed to produce the resources and absorb the waste of a given population. This land or water can be anywhere in the world, and can be quite distant from the point of consumption. The same areal unit of measurement expresses supply (how much can be regenerated each year) and demand (how much is being drawn out or used each year).

The originators of the ecological footprint (Bill Rees and Mathis Wackernagel at UBC) emphasized that it is primarily an educational tool. They deliberately adopted conservative methods for its calculation. For example, instead of representing energy used by the land that would be needed to grow the feedstock for alternative fuels (which is enormous), only the area required to absorb carbon dioxide from the combustion of fossil fuels is considered (this is still very large, and it accounts for a large portion of most footprints). The ecological footprint does not attempt to address important but non-renewable resources like metals, or account for issues like toxicity, biodiversity, land availability to other species or other key ecological issues.[2]

Ecological footprints are often expressed on a per capita basis for a particular population. This tends to flatten attention to differential responsibility within that population for the total footprint. Since total impacts are attributed to persons, per capita footprints also fail to distinguish between the impact of individual activities and the impacts of military, marketing and other activities that may be deemed 'wasteful'.

However, ecological footprints have several advantages over other metrics of sustainability.[3] Like the money unit in economics, it provides a common basis for evaluating different activities. All are expressed in terms of area of land (see more on this below), something everyone can understand. The role of area in biophysical relationships also connects to the 'strong' sustainability conception. It thus often provides a useful contrast to the perspectives provided by neoclassical and other pro-market economic models that ignore non-private nature. It should especially be noted that it includes but is more ecologically comprehensive than the carbon footprint.

The general proposition of this study is that calculating and considering the KPU ecological footprint can be an effective way to inform discussions of sustainability issues at this university.

2.0 Ecological Footprint Methodology and Applications

2.1 Methodology and Metrics

2.1.1 Land Use Types and Global Hectares

The unit of measurement of the ecological footprint is the global hectare. This is a hectare of land of average world bioproductivity. Because time is required for natural production it is expressed in per annum terms – global hectare per annum, or gha.

After excluding land with minimal bioproductivity (e.g. ice caps, deserts) there are six different sub-categories of land that compose the area measured by global hectares. Each represents one of the main demands human activities place on the earth's ecological processes. The definition of these land categories is also informed by the type of data generally available (Wackernagel and Rees, 1996).

The Global Footprint Network (GFN)[4] is the leading source of data for and advice on calculating ecological footprints. It periodically calculates and reports the total area of each of these types of land on earth. It also calculates their current relative biophysical productivity, as both the productivity and the area of that type of land change may over time (e.g., as cropland is converted to built land).

Figure 4: Types of bioproductive land [v]

Crop land: most productive land for agriculture

Pasture land: for grazing domestic animals for human consumption

Forest land: forests that yield timber products

Productive sea space: aquatic areas that yield majority commercial fishing

Built land: roads and buildings

Energy land: land required to sequester carbon emissions

Source: http://www.steppingforward.org.uk/tech/footprint.htm

Figure 5 below reports the relative biophysical productivities in Canada assumed for this report. In the year for which this data was calculated, cropland in Canada was 2.64 times as productive as land of world average bioproductivity.

Figure 5: Equivalence factors for Converting Different Land Use Areas to Global Average Productivity

Footprint Area Type	Equivalence Factor
Crop Land	2.64
Grazing Land	0.50
Other Wooded Land	0.50
Forest	1.33
Marine	0.40
Inland Water	0.40

Source: Acosta and Moore, 2009, p.21

2.1.2 'Conversion Rates' to Global Hectares

Conversion rates quantify the relationship between the amount of resource produced by a particular product or process or the waste that must be absorbed and the corresponding area in global hectares that is required. 'Conversion rates' are calculated to express the global hectares of land required for each type of resource that is drawn from the environment or that must absorb waste. They vary on the basis of what kind of land is required (e.g. cropland vs. forest land) and the yield of that land for the particular resource in question (e.g., the weight of potatoes it can grow vs. the weight of tomatoes).

For example, the conversion rate for a given amount of a particular food type expresses the number of global hectares equivalent to the area of cropland required to grow that amount of that food type, plus the global hectares equivalent to the area of forest land required to absorb the greenhouse gases associated with the energy that is embodied in that amount of that food type.

2.1.3 Compound vs. Component Methods

There are two general approaches to calculating ecological footprints, the compound method and the component method.

2.1.3.1 Compound Method

The compound method is a 'top down' approach where the total global hectares available are compared to the total global hectares demanded. It takes national-level economic and other data and adjusts it to take into account imports and exports for that country. The national totals are then often expressed in per capita terms, and subdivided into conventionally-defined economic sectors for more detailed evaluations. The Global Footprint Network calculates these national ecological footprints and aggregates them to the global level on an annual basis.

When desired, national data can be applied to sub-national populations, for example, by assuming that the local per capita footprint for food is similar to the national per capita footprint. Such per capita footprints for a local level might also be adjusted to reflect per capita local incomes being higher or lower than the national average.

The compound approach is the most common and reliable method. The national-scale data it employs is usually the most reliable available, and is comprehensive and comparable across jurisdictions. The Global Footprint Standards[6] established by the GFN require that all ecological footprints follow the compound approach, or that compound calculations be reported for purposes of comparison if other approaches are used.[7]

The main disadvantage of the compound approach is insensitivity to conditions that apply in local contexts or particular processes. For example, when considering the footprint of energy use, the compound approach assumes the same conversion rate applies as that for the county as a whole even though the local source of energy might be very different. Similarly, the national pattern of food supply includes the overall imports and exports of food while local patterns of food consumption may be very different.

The compound approach often breaks down the national data into major sub-categories that correspond to conventionally-defined economic sectors. However, it does not extend down into the many minor categories below these levels. For example, it may report data for the auto sector, but not for a particular brand and model of car, or for all paper manufacturing but not for paper that is manufactured from recycled as opposed virgin fiber.

While national data can be projected on a per capita basis to a local or regional scale of analysis, it is hard to apply this data to other types of units, such as institutions. For example when considering the ecological footprint of KPU we need to distinguish between resources used and waste produced by people in their roles at KPU rather than in all their life roles.

2.1.3.2 Component Method

The component method is a 'bottom up' approach that relies on more specific calculations of the resources used and waste produced by particular products and through particular functions. In principle, a complete life cycle analysis of these products is conducted, following such products or processes from 'cradle to grave'. In theory a complete inventory of all the energy and material inputs and environmental releases are addressed.[8]

The impact of the use of a vehicle, for example, is determined by compiling data on area and type of land required to produce its components, the energy embodied in its manufacturing and maintenance, the energy used to operate the vehicle (depending on fuel consumption and distance travelled), and its share of the land occupied by roads, parking, etc. These are aggregated to express the global hectares associated with the vehicle.

The main advantage of the component method is its sensitivity to local contexts, and the attention to more specific products and processes than is typically possible using compound methods. The component method can also be more effective pedagogically, because the impact of specific activities is often better understood than the somewhat abstract methodology of the top down, compound approach (Wackernagel and Rees, 1996).

The major drawback to the component approach is the effort needed to develop the conversions rates needed to calculate the footprint of each individual component. There is no common source of data similar to that provided for compound approaches by the Global Footprint Accounts published annually by the GFN.

A key liability of component calculations is the lack of consistency or comparability. Because of limitations in data availability they often vary in terms of the stages in the total life cycle considered. Regional differences in how products are produced and waste is absorbed, and the use of different sources of data for the same phenomena are also complicating factors.

However, the component method is the only realistic way to calculate the footprint of KPU as an institution. The two key areas of effort are to compile the necessary data on resources used and waste produced and the conversion rates to express resources and waste in global hectares.

This study relies on conversion rates that have been calculated and reported by footprint experts. They include an early book on the subject by Chambers et al (2000), an article reporting on a detailed study of the ecological footprint of York in the UK by Barrett (2012), an article by Kissinger et al (2013) that compiles various conversion rates, a dissertation on the Vancouver ecological footprint by Moore (2013), the calculation of the ecological footprint of BCIT by Acosta and Moore (2009), and an on-line tool provided by the Carnegie Mellon Life Cycle Analysis site.[9]

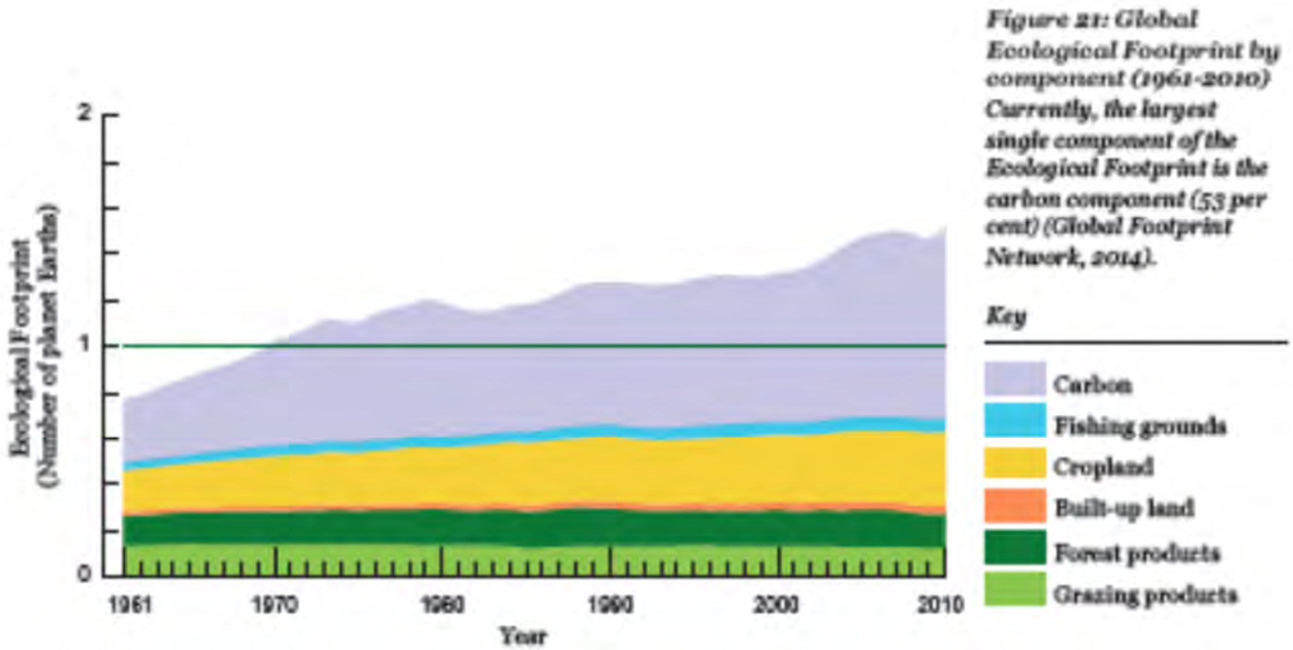
2.2 Selected Examples of Ecological Footprint Calculations

To provide context for the KPU ecological footprint it is useful to review a few points about footprints calculated at larger scales and for other universities.

2.2.1 World Results and Trends

The most general evidence that our current world is not being managed sustainably is provided by ecological footprint calculations at the global scale. These studies indicate that humanity has exceeded ‘one-planet living’ for approximately the last 45 years.

Figure 6: Global Footprint by Land Type



Source: Living Planet Report, p. 32 http://awsassets.wwf.ca/downloads/lpr2014_low_res__1_.pdf

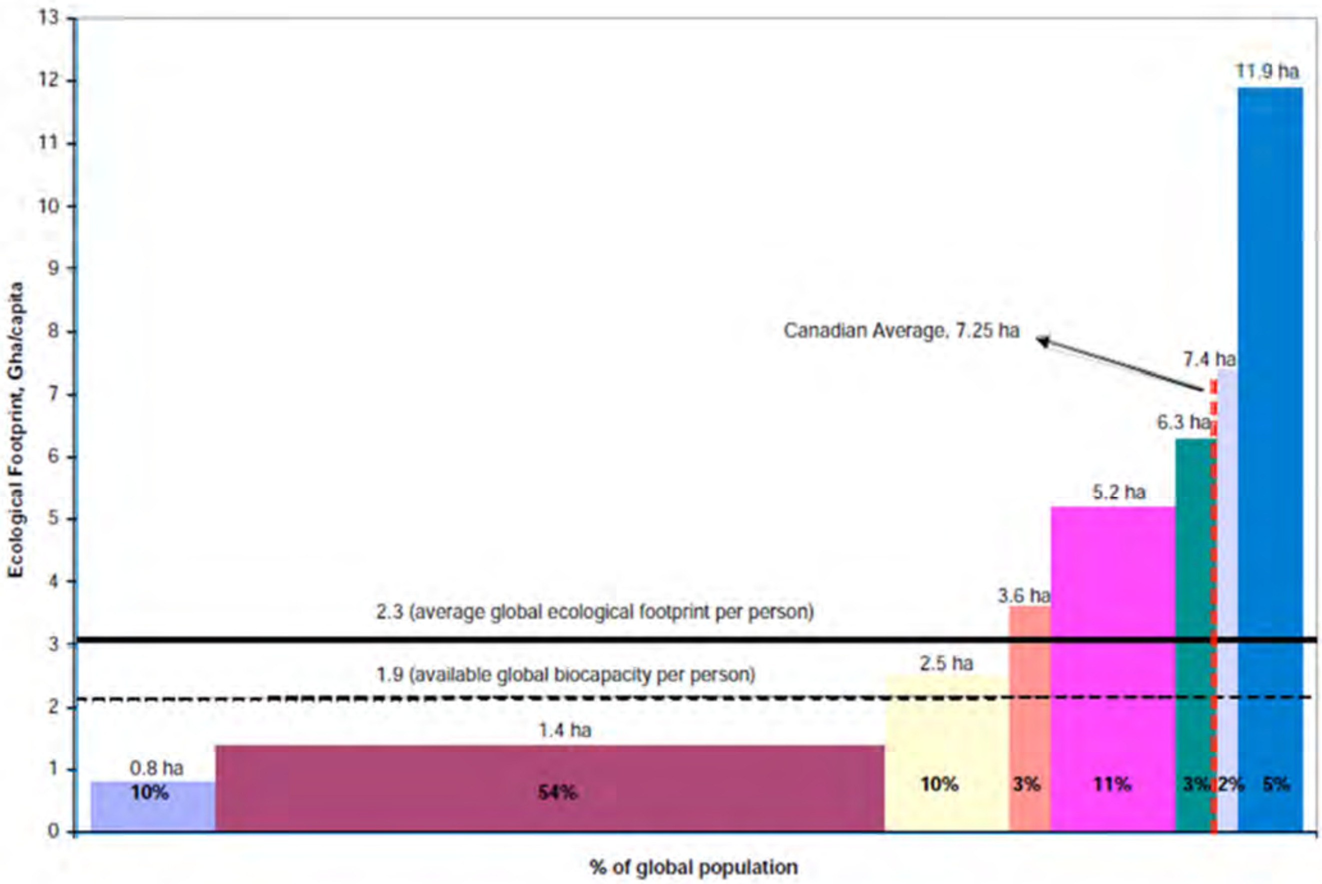
As indicated by Figure 6 we currently use the equivalent of 1.5 planets to provide the resources we use and to absorb our waste. Expressed differently, it now takes the earth one year and six months to regenerate what we use in a year. Moderate UN scenarios suggest that if current population and consumption trends continue, we will need the equivalent of two Earths to support us by 2030 and almost three by 2050.[10]

2.2.2 National Level Footprints

One of the main points evident from comparisons of national ecological footprints is the “North-South divide’. The per capita footprint of about two-thirds of the world’s population is below their per capita share of planetary capacity; they are, on average, living ‘sustainably’ in the sense this term is used here. Meanwhile the per capita footprint of developed countries like Canada (7.25 gha) is far above the per capita global hectares available, which is now about 1.9 gha, or even less.

The Living Planet Report 2014 reports that Canadians have the 11th largest per capita footprint of countries in the world. The natural productivity of Canada’s land mass is still greater than consumption by Canadians, but we are using approximately 3.7 times our per capita share of the Earth’s annual productivity. The report documents the global trend of increasing demand for resources by a growing population that is putting tremendous pressure on our planet’s biodiversity. It is also threatening our future security, health and well-being. For example, declining biodiversity threatens not only the balance of our ecosystems, but also economic opportunities.[11]

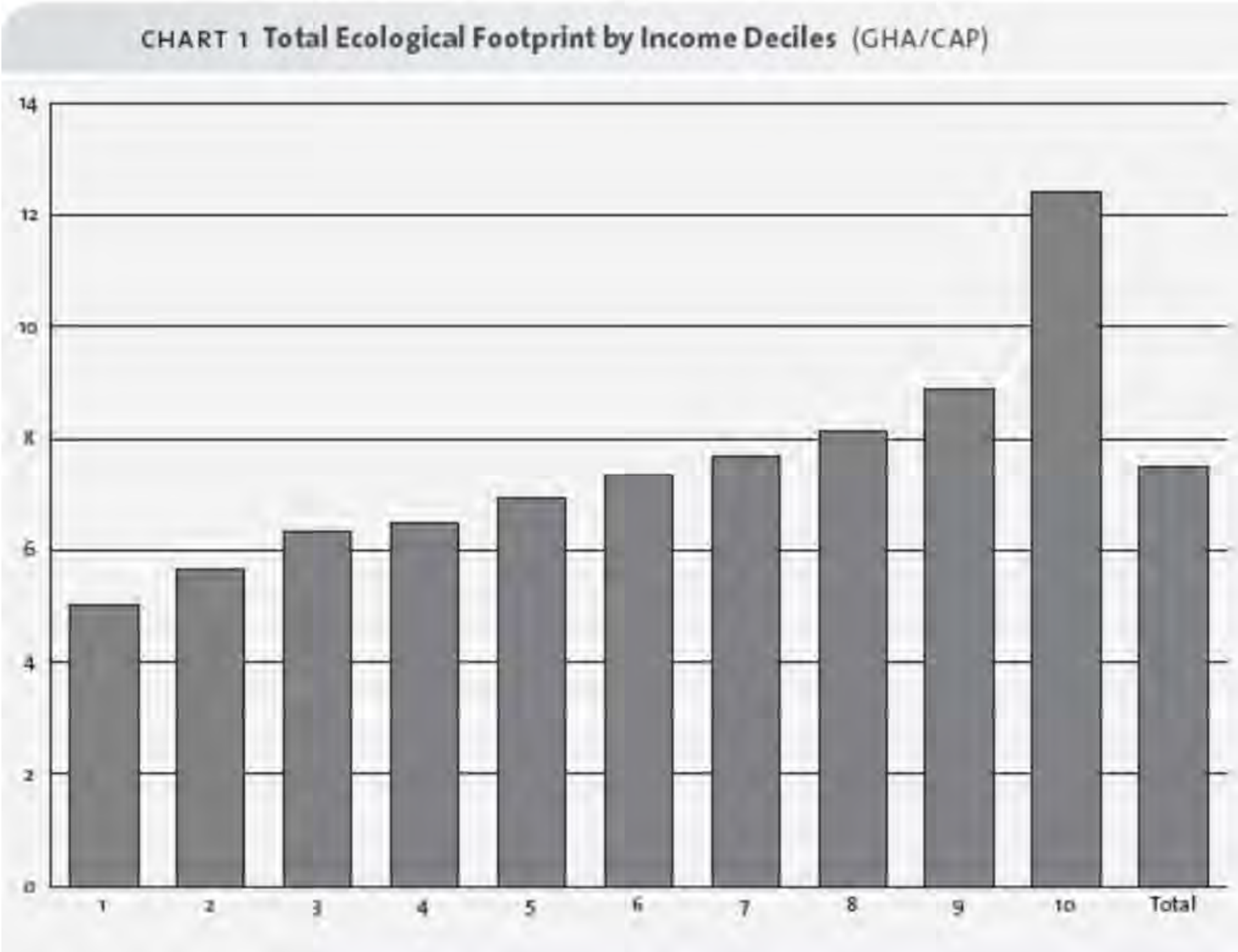
Figure 7: Who is Sustainable, and Who is Not?



Note: 1996 data from the 2000 *Living Planet Report*, based on similar chart originally published in the 2000 *Living Planet Report*.

Having noted Canada's national per capita footprints, it is important to note that Canadians do not contribute equally to this average footprint. A conservative calculation of the variation in footprint size by family income decile[12] is reported in Figure 8 below. The footprint of top decile families is more than twice that of bottom-decile families.

Figure 8: Ecological Footprint in Canada by Income Decile:



Source: MacKenzie et al, Size Matters: Canada's Ecological Footprint, by Income, Canadian Centre for Policy Alternatives, 2008, p. 13.

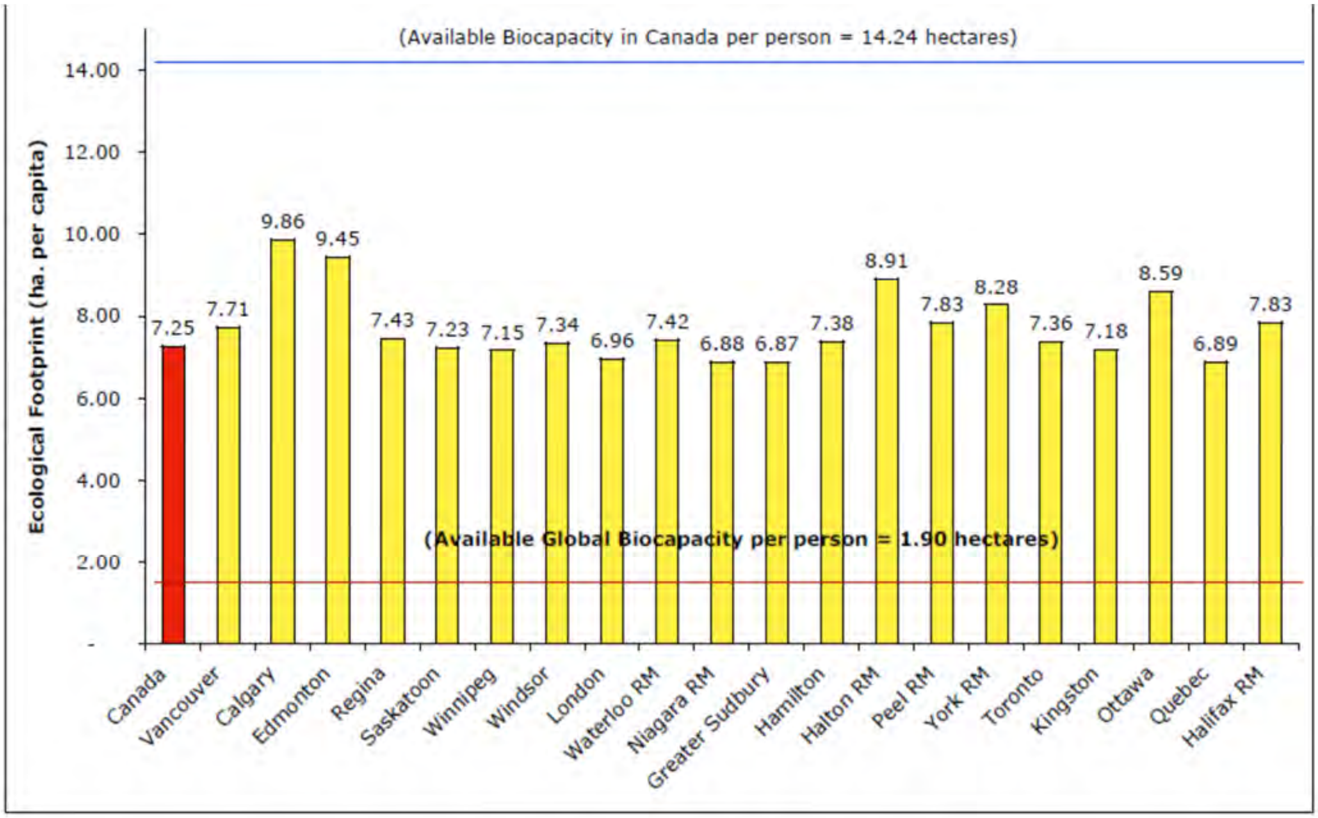
This study also showed that transportation and housing are responsible for most of difference in footprint areas by family income.[13]

2.2.3 Metropolitan Regions in Canada

The Federation of Canadian Municipalities commissioned a study of ecological footprints of cities across Canada in 2001. As seen in Figure 9, this study reported that Vancouver's footprint is slightly higher than the average of the municipalities reported.

Surrey, Richmond and Langley were not addressed separately by this study. It instead projected the per capita numbers for Vancouver to the metropolitan scale. Although the per capita rate for Vancouver is probably less than the region as a whole, the latter is a useful reference point, e.g. as reported in Figure 10 further below, the Metro Vancouver footprint is 57 times its land area.

Figure 9: Canadian Municipal Ecological Footprints



Source: Wilson, Jeffery & Anielski, Mark. (2005). Ecological Footprints of Canadian Municipalities and Regions. The Federation of Canadian Municipalities Quality of Life Reporting System. Retrieved from http://www.fcm.ca/Documents/reports/Ecological_Footprints_of_Canadian_Municipalities_and_Regions_EN.pdf

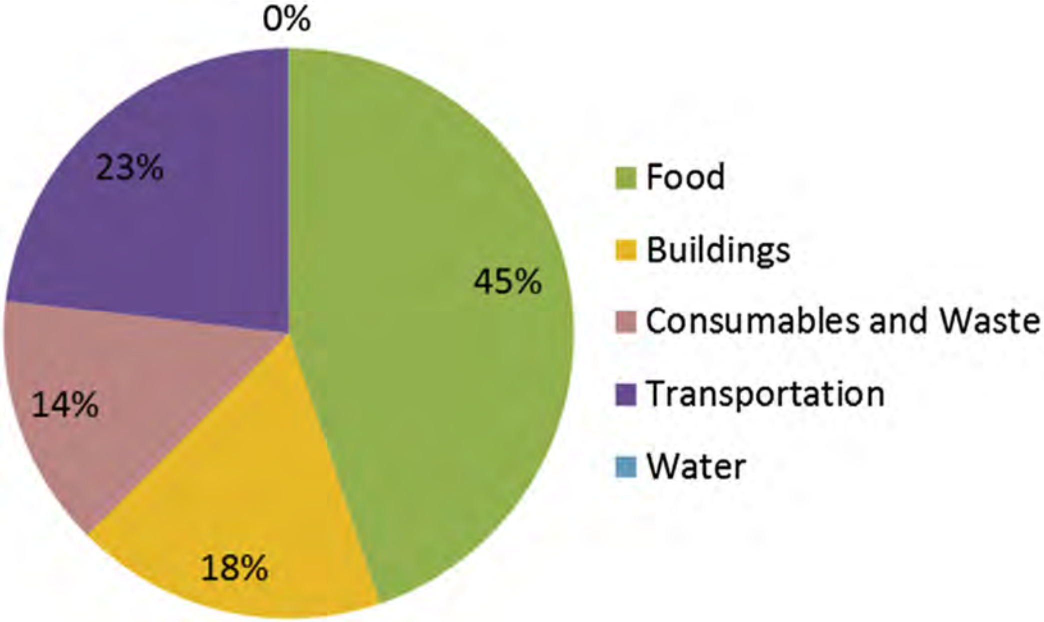
Figure 10: Ecological Footprints, Toronto and Vancouver Municipalities and Metropolitan Areas

City or Region	Population (2006)	Per Capita Eco-Footprint (gha)	Area (hectares)	Total Eco-Footprint (gha)	Ratio of EF to Actual Area
Vancouver	578,041	7.71	11,400	4,456,696	390
Metro Vancouver	2,116,580	7.71	278,736	16,318,832	57
Toronto	2,503,281	7.36	63,000	18,424,148	292
Greater Toronto	5,555,912	7.36	712,500	40,891,512	57

Source: Bill Rees*, 2010 Getting Serious about Urban Sustainability*, in Bunting, et al, Canadian Cities in Transition, Don Mills: Oxford, p. 77.

A more detailed study of Metro Vancouver's ecological footprint in 2006 was carried out by Moore et al (2013). It found the total footprint was 10,071,670 gha, or about 36 times larger than the region itself. The per capita ecological footprint was 4.76 gha, nearly three times the per capita global supply of biocapacity.[14] As indicated by Figure 11 this study found that food accounted for the largest share, followed by transportation.

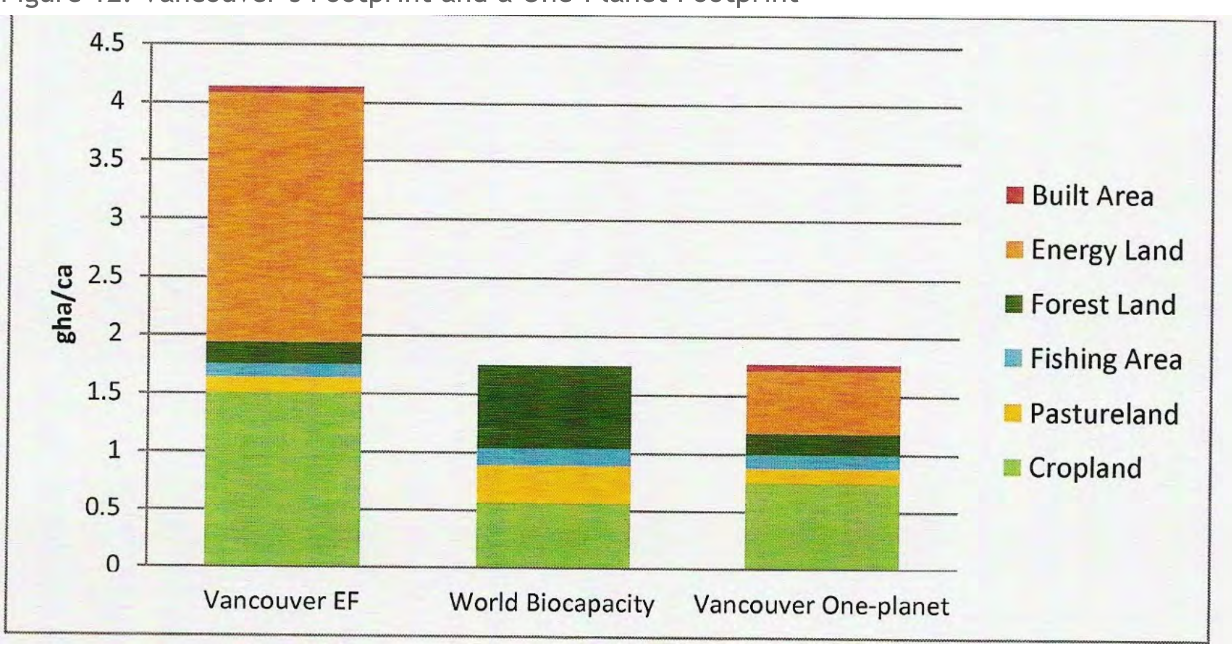
Figure 11: Metro Vancouver Ecological Footprint by Component, 2006



Source: Moore, Jennie & Kissenger, Meidad & Rees, William E. (2013). An Urban Metabolism and Ecological Footprint Assessment of Metro Vancouver. *Journal of Environmental Management, 124.*

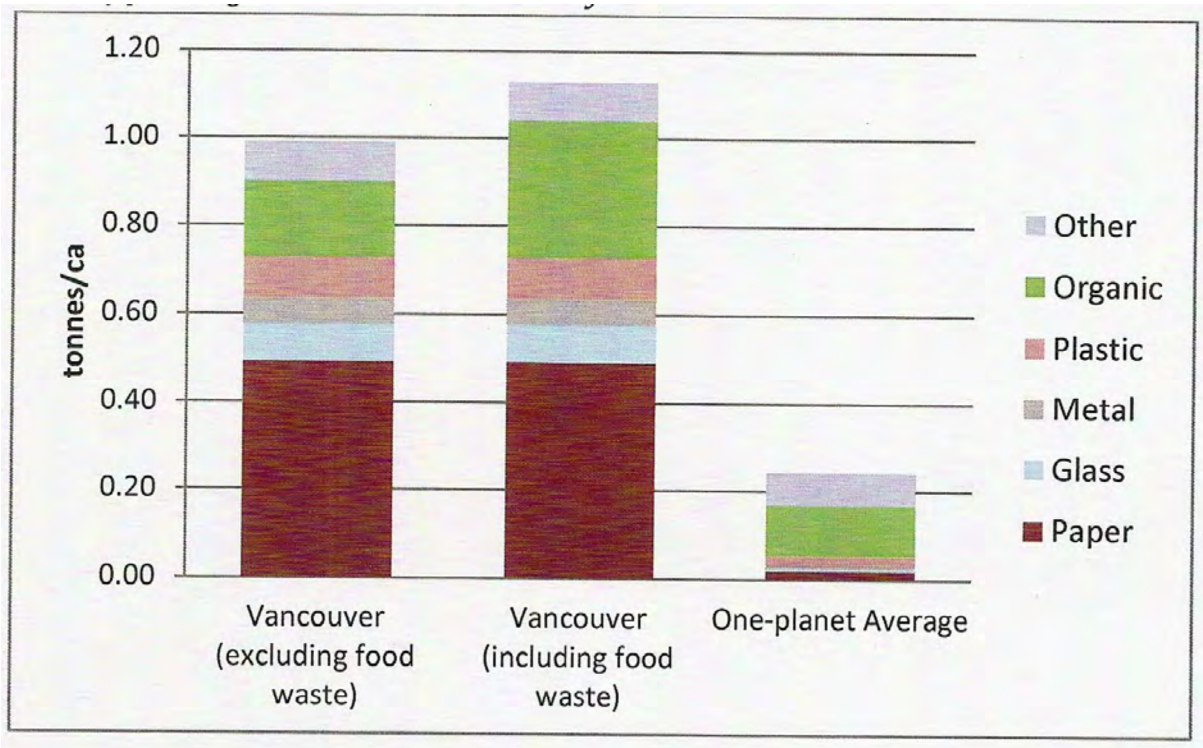
In her earlier Ph.D. dissertation, Moore considered what it would mean for Vancouver to adopt 'fair share one-planet living' (Moore, 2013). Figures 12, 13 and 14 below demonstrate that radical changes in consumption patterns would be required to reach this goal. The scale of change is one indicator of the challenge faced by KPU - and everyone else. The drastic reduction in material throughput and big changes in diet are notable examples of the change entailed for our ways of life.

Figure 12: Vancouver's Footprint and a One-Planet Footprint



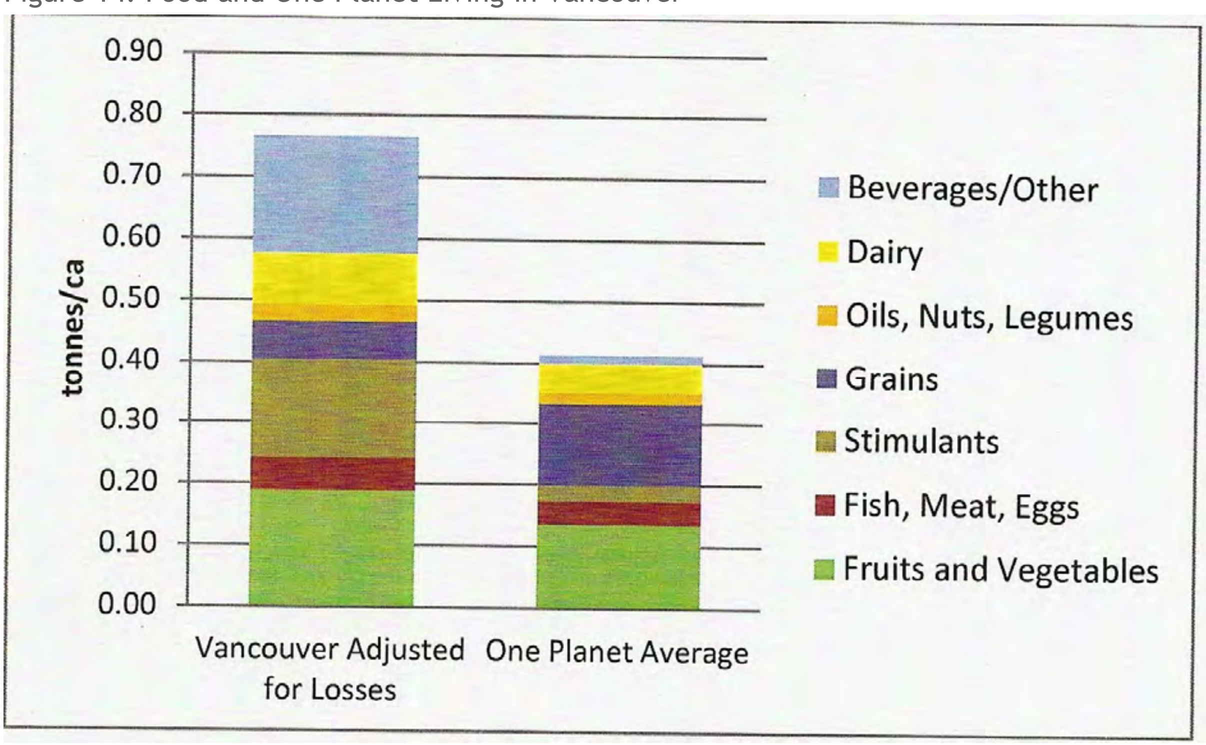
Source: Moore, Getting Serious About Sustainability In Canada: Exploring the Potential for One-Planet Living in Vancouver, Ph.D. Dissertation, UBC, 2013, p. 143.

Figure 13: Material Usage in One Planet Living in Vancouver



Source: Moore, Getting Serious About Sustainability In Canada: Exploring the Potential for One-Planet Living in Vancouver, Ph.D. Dissertation, UBC, 2013, p. 159.

Figure 14: Food and One Planet Living in Vancouver



Source: Moore, Getting Serious About Sustainability In Canada: Exploring the Potential for One-Planet Living in Vancouver, Ph.D. Dissertation, UBC, 2013, p. 148.

2.2.4 EFs at Universities

Figure 15 reports ecological footprints that have been calculated for a number of universities and colleges around the world. Thompson River University and BCIT are added to provide local comparisons, along with earlier ecological footprints for the years 2005 and 2011 that were calculated for KPU. There is considerable variation in the coverage and methodology employed for these calculations. The difference between the KPU footprints in 2005 and 2011 is mainly due to changes in coverage and methodology rather than actual footprint. Such methodological differences probably also account for much of the reported variation between universities.

Figure 15: Ecological Footprints of Universities

Institution	Total Footprint (gha)	Per Capita Footprint (gha)
University of Illinois	97,601	2.66
University of Redlands	5,700	0.90
University of Newcastle, Australia	3,592	0.19
Holme Lacy College (UK)	296	0.57
Northeastern University (China)	24,787	1.06
University of Toronto Mississauga	8,744	1.07
Colorado College	5,603	2.24
Ohio State University, Columbus	650,666	8.66
Willamette University	7,804	2.30
University of East Anglia	23,455	7.30
Campus de Vegazana University León	6,300	0.45
University of Santiago Compostela	5,159	0.16
Thompson River University[15]	2,985	n/a
BCIT Burnaby Campus[16]	16,590	0.49
KPU, 2005[17]	2,977	0.17
KPU, 2011[18]	7,325	0.35

Source: Except as indicated otherwise, data from Lambrechts, Wim & Liedekerke, Luc Van. (2014). Using Ecological Footprint Analysis in Higher Education: Campus Operations, Policy Development and Educational Purposes. Ecological Indicators. Retrieved from https://owl.english.purdue.edu/owl/resource/560/10/

3.0 Description of EF calculation at KPU – Methods and Results

3.1 'Coverage' of Ecological Footprint

The first issue is what should be included in the ecological footprint calculation. For an institution like KPU it should obviously include the activities or functions that very directly relate to the purpose and operation of the institution. This would include the food consumed on campus and the energy used to power the buildings. However, clothing worn by KPU students and employees and the food they consume at home should not be included as they are arguably better understood as contributing to personal footprints rather than the footprint of the institution.

Daily or weekly transportation to and from campus is a prime example of a ‘border’ case. It is included in this study, as in most campus footprint calculations. Also included here is an estimate of the air travel by international students. The latter presumes a very broader perspective on the ‘borders’ of the institution, but was included here because the size of this component is so significant.

The other main issue of coverage is what stages of the life cycle of a product or process are included. Ideally, all stages should be represented, from the extraction of the resource though the processes of manufacturing, distribution, to the use of the product and finally it’s recycling or waste disposal. However, as will be discussed below, the ‘conversion’ rates used do not always include all life cycle stages. In a number of cases only the embodied energy for manufacturing and distribution is included. Other stages that should ideally be considered, including the land and materials used to produce the good, the energy used during its service life, and the impact of its absorption as waste were not always fully included.

Finally, the components to be included in the calculation are partly affected by the sources of the required data, which is influenced by how administrative units on campus are organized. For example, responsibility for purchasing paper is divided among several different units, and there are several different providers of food services. The reliability of the data coverage is probably reduced by this dispersal of responsibility.

3.2 Data Collection

As in previous years’ calculation of the KPU ecological footprint, the KPU Facilities Department played a key role in providing data or directing us to and facilitating our requests to other departments. The following lists areas of data compiled for various components of the footprint and the departments from which data was requested and received by the Geog 4501 instructor on behalf of the class.[19]

Electricity and gas usage	Facilities Dept.
Recycled materials and waste	Facilities Dept., Environmental Protection Program classes
Water and sewerage	Facilities Dept.
Washroom TP and paper towels	Facilities Dept., Finance Dept.
Campus buildings and furniture	Finance Dept.
Food services, vending machines	Sodexo, Ryan Vending, Coca Cola, KSA
Computers and telecommunications	Info. Tech. Dept., Kwantlen Faculty Association (KFA)
Copy and writing paper	Print Shop, Facilities Dept., Finance Dept., KFA
Student and staff postal codes	Institutional Analysis Dept.
Employee air travel	Finance Dept.
KSA Shuttle	Kwantlen Student Association (KSA)
KSA transportation survey	Kwantlen Student Association (KSA)

3.3 Calculations and Results

3.1.0 Overall Results

Figure 16 below provides and overview of the components of the KPU ecological footprint and their corresponding footprint areas in global hectares per annum. Each component is then discussed below, with additional details reported in the Appendix.

Figure 16: KPU Ecological Footprint 2013: Summary of Components, Amounts and Footprints in GHA

Campus populati	Students	19,626	93.9
	Staff and Admin	535	2.6
	Faculty	732	3.5
	TOTAL	20,893	100.0
Category	**Sub cat**	**Gha**	**%**
Food	SODEXO total		
	Tim Hortons		
	Grassroots		
	TOTAL	**185.7**	1.8
Vending machines	Ryan Vending		
	Coca Cola		
	KSA water		
	TOTAL	**44.5**	0.4
Paper	KSA		
	KFA		
	KPU office		
	KPU Printing		
	Bookstore		
	Library		
	TOTAL	**387.2**	3.8
Computers, printers	KSA		
	KFA		
	KPU computers		
	KPU printers		
	KPU network		
	TOTAL	**307.8**	3.0
Furniture	TOTAL	**517.9**	5.0
Water and sewer	TOTAL	**12.3**	0.1

Energy	Natural gas		
	Electricity		
	Vehicle gas		
	TOTAL	**1023.8**	10.0
KPU campus land	TOTAL	**153.7**	1.5
Buildings	TOTAL	**758.8**	7.4
Recycle materials	TOTAL	**57.9**	0.6
Unrecyled waste	TOTAL	**67.5**	0.7
Auto transportation	Auto parking		
	Auto student		
	Auto faculty		
	Auto staff		
	Employee milage		
	Employee car rental		
	Car2Go		
	Auto share of BC roads		
	TOTAL	**3199.0**	31.1
Transit transportatio	Student transit		
	Faculty transit		
	Staff transit		
	KPU Shuttle		
	Transit share of BC roads		
	TOTAL	**246.4**	2.4
Air transportation	International students		
	Faculty and staff travel claims		
	TOTAL	**3326.0**	32.3
Total Campus Footprint (ha)		**10288.482**	100.0
Footprint per non FTE student		**0.524**	
Footprint per non FTE person		**0.492**	

Source: See text below and Appendix

3.3.1 Campus Area, Buildings and Furniture

3.3.1.1 Campus Area:

The four campuses of KPU have an area of 61.74 h, of which 9.69 h is buildings, 0.34 h is forest and 3.17 h is parking lots.[20] A hectare of Canadian forest is 1.33 times as bioproductive as a global hectare, so .45 gha was deducted from the KPU footprint, as this area remains bioproductive. The rest of the campus area is treated as having been removed from cropland, which is 2.64 times as productive as world average bioproductive land. The 3.17 h of parking lots are counted under auto transportation and so are excluded from this component. The result is that the footprint of the campus land component is 154 gha, or 1.5% of the KPU total ecological footprint.

3.3.1.2 Buildings:

It is difficult to calculate the volume of wood, steel, glass, concrete and other materials used to construct the buildings on campus in order to estimate the embodied energy and the area of land required to produce these materials.[21] Since the resulting footprint is an annual measure it would also be necessary to divide these amounts by the assumed service life of the buildings (for concrete buildings this is usually considered to be about 75 years).

The procedure adopted in this study was to input the 2013 amortization amount for buildings and fixed assets reported in the KPU Financial Statement 2013-2014 (p. 15) into the life cycle analysis tool provided by Carnegie Mellon University.[22] This tool basically adds several ‘environmental impact’ sectors to the 428 conventional economic sectors in an input-output model.

Input output models can quantify the ‘share’ of activity in each of the other sectors that are related to activity in a given sector. When the $6.121 million amortization amount for KPU buildings in 2013[23] is entered under the Construction sector/Commercial, Health and Educational sub-sector, the tool calculates that the volume of CO2e generated in all economic sectors directly and indirectly necessary for this amount of construction activity at KPU is 3,610 tCO2e, which requires about 758 gha to absorb.[24]

The Carnegie Mellon tool also reports that the land area corresponding to the contribution by other sectors to the construction sector/subsector is another .516 h.[25] Assuming the land used would have been forest land originally, this area is multiplied by the forest land equivalence factor of 1.33. The year’s total ecological footprint for KPU buildings is estimated to be 759 gha, or about 7.4% of the total KPU footprint.

3.3.1.3 Furniture and Equipment:

The Carnegie Mellon tool was also used to estimate the footprint of the $3.8 million amortization amount for furniture and equipment reported by the KPU Financial Statement 2013-14 (p. 15).[26] The tool reports that the total emissions from this amount of production in the office furniture manufacturing sector were 2,460 tCO2ewhich corresponds to.59 h of land. The result is a total annual ecological footprint of 518 gha, or 5.0% of the KPU total footprint.[27]

3.3.2 Energy

The two forms of energy consumed are natural gas (to heat buildings and water) and electricity (for lights, ventilation, computers, etc.). A small amount of gas is used by KPU vehicles.

KPU Energy Consumption Records 2013 (p. 3) report that 45,114 GJ of natural gas were consumed. This is equivalent to 924,053 m^3 of gas according to the rate reported by Natural Resources Canada.[28] When the latter is multiplied by the conversion rate to global hectares of .000465 gha/m3 gas reported by Chambers, 2000, p.89, the ecological footprint of natural gas is 430 gha.

The same source reports that KPU consumed 1,113,788 kWh of electricity, or 11.14 Gwh. Different means of generating power have different ecological footprints, and exports and imports of energy from other jurisdictions add to the difficulty in identifying the footprint of power provided by BC Hydro. The following breakdown was calculated: Hydro 70.83%, thermal (gas) 26.01%, biogas/other 2.97%.[29] The conversion rates of 42.5, 94.0 and 12.3 gha/kWh for these sources of power generation are averages of the (considerable range in) values reported by Chambers, 2000, p. 83).The result is an ecological footprint for KPU electricity consumption of 588 gha.[30]

The total energy footprint of KPU is 1024 gha, or 10.0% of the total. However, thanks to the diligent efforts to implement energy saving measures by the Facilities Department, KPU uses less gas and electricity now than it did 15 years ago despite a significant increase in campus infrastructure and population. KPU’s ecological footprint for gas plus electricity was 7.7% higher in 1998 than in 2013, despite the building area being 26% smaller in 1998 than in 2013.[31]

3.3.3 Food and Beverage

The food services on campus are the cafeteria services by Sodexo, Sodexo's Tim Horton's franchises, and the KSA's Grassroots Cafe on Surrey Campus.

Weekly orders by Grassroots in 2011 (see Figure 17 below) were projected for the entire year and used because data for 2013 were not available. KPU's population has increased since then so it is likely that the amount of food served has also increased.

Figure 17: Grassroots Café's Weekly Food Orders, Conversion Rates and Results (CGS)

Food Product	Weight (kg)	Conversion Factor	Footprint (gha)
Seafood	0	0.0045	0
Meat and poultry	560	0.0069	3.86
Vegetables	2193	0.0004	0.88
Grain	800	0.0017	1.36
Dairy	960	0.0011	1.06
Fruits	997	0.0005	0.5
Coffee	720	0.00118	0.85
Tea	0	0.00118	0
Beverages	8278	0.00074	6.14
Beer	750	0.00018	0.13
Total	29.51		14.78

Source: Food order data courtesy of Grassroots, conversion factors from Chambers, 2000.

In addition to the food, the waste stream should also be considered. Figure 18 reports the results of a survey of organic waste from Grassroots Cafe. It was used to estimate the annual waste stream of 2.308 tonnes[32], whose footprint was calculated to be 2.317 gha on the basis of the energy used to transport it to the landfill, the energy used for landfill operations and the methane produced by its decomposition.[33]

Figure 18: Grassroots Café's Waste

Material	Weight (kg) Grassroots - Tues	Weight (kg) Grassroots – Thurs	Average weight (kg) per week
Organics and compost	15.1	11.8	67.25
Recyclables	8.1	2.4	26.25
Paper cups	0.34	0.34	1.7
To-go-containers	1.9	1.8	9.25
Paper towels	1.7	1.5	8.0
Garbage	3.5	1.8	13.25
Cardboard	2.0	4.4	16.0
Total	32.64	24.04	141.7

Source: Robbins, T., 2014, ENVI 2900 Research Project - Waste Audit

The weight of various foods and supplies purchased in 2013 for the cafeterias were provided by Sodexo manager Erin Mclean. The groupings in these reports were not well matched to those for which conversion rates to global hectares are available, which limits the precision and coverage of these footprint calculations.

While conversion rates from Chamber were used for Grassroots Café, the footprint for the Sodexo cafeterias was calculated as described in Figure 19. Rates of embodied energy and crop yield land for various food products as reported by Acosta and Moore, 2009 were used. The following are sample calculations for beef and produce.[34]

Figure 19: Calculation Method for Footprints of Sodexo Beef and Vegetables

What	Amount and units	Source
Sodexo 462.4 kg of beef 2013	.4624 t beef	(Sodexo)
embodied energy for beef production	67.9 MJ/ t beef	(Acosta, p.20)
Resulting CO2 to be absorbed	19.3 t CO2e/ t beef	(Acosta. p. 20)
Less the 25% absorbed by oceans	14.475 tCO2e/t beef	(Acosta, p 22)
CO2 sequestration rate by CDN forests	.97 tCO2e/ha	(Acosta, p. 21)
Forest land to absorb CO2	14.923 ha/t beef	(=14.475/.97)
Forest land equivalence factor	1.33	(Acosta, p 21)
Energy land in global hectares	19.847gha/t beef	(=1.33*14.923)
Yield factor for beef (land to raise beef)9.64 h	(Acosta, p 20)	
Grazing land equivalence factor	0.5	(Acosta, p 20)
Food land needed to raise beef	4.82 ha/t beef	(=9.64*.5)
Energy and food land to produce beef	24.667 gha/t beef	(=19.847+4.82)
Footprint of Sodexo beef	11.406 gha	(=.4624 t beef*24.667 gha/t)
Sodexo vegetables 2013	5.66 t veg	(Sodexo)
embodied energy for veg production	22.0725 MJ/ t veg	(Acosta, p.20, ave. 4 veg)
Resulting CO2 to be absorbed	2.4 t CO2e/ t veg	(Acosta. p. 20, ave. 4 veg)
Less the 25% absorbed by oceans	1.8 tCO2e/t veg	(Acosta, p 22)
CO2 sequestration rate by CDN forests	.97 tCO2e/h	(Acosta, p. 21)
Forest land to absorb CO2	1.856 ha/t veg	(=1.8/.97)
Forest land equivalence factor	1.33	(Acosta, p 21)
Energy land in global hectares	2.468 gha/t veg	(=1.33*1.856)
Yield factor for veg (land to raise veg).	035 ha/t veg	(Acosta, p 20, pot. + tom.)
Crop land equivalence factor	2.64	(Acosta, p 20)
Food land needed to raise veg	.092 gha/t veg	(=.035*2.64)
Energy and food land to produce veg	2.56 gha/t veg	(=2.464+.0924)
Footprint of Sodexo veg	14.49 gha	(=5.66 t veg* 2.56 gha/t)

Comparing the calculation for beef to that of vegetables makes clear the different scales of their ecological impact. The beef footprint per ton is almost 10 times that for vegetables (24.67 gha/t vs. 2.56 gha/t).

Data was not available for Tim Hortons, so as a ‘placeholder’ calculation it was assumed its footprint is half of the Sodexo cafeterias. No separate calculation was made of the waste from Sodexo cafeterias or Tim Hortons, but its footprint is included in the overall waste category for KPU. The combined footprint estimated for Grassroots Café, Sodexo cafeterias and Tim Hortons was 207 gha, or 1.8% % of the KPU total.

3.3.4 Printing and Washroom Paper

The total weight of paper reported by various areas of KPU during 2013 was 370 tonnes, with a total ecological footprint of 323 gha, or 3.8% of the total KPU footprint (see Appendix 7.1.3 for details and sources of data).

Of this, 151 tonnes was toilet paper and paper towels in the washrooms, 20 tonnes were used in KPU offices, and 44 tonnes were used in the Print Shop. Much smaller amounts were reported by the KSA, the KFA and Library acquisitions. Different conversion rates were used for washroom paper as opposed to fine paper, and to account for the percentage of fibre in copy paper that is recycled.

3.3.5 Recycled Waste and Landfilled Waste

Annual waste data was provided by the Facilities department but the data did not break down the types of waste in a way that was useful for our purposes. However, an audit of the waste on Langley Campus was carried out by Environmental Technology Program (EPT) students. Figure 20 reports the breakdown of waste by type. We applied these shares to the total waste reported by the Facilities Department to estimate the composition of total KPU by waste by type.

Figure 20: Waste by Type Based on EPT Audit of Langley Campus

Solid Waste by Category	EPT Waste Collection Data from November 15, 2014 (kg)	Percentage from Total Waste Collected (%)	Totals of KPU Waste by EPT Waste Audit's Category Percentages (kg)
Garbage	41.104kg	36.42%	176703.65
Non-Recyclable Plastic	6.586kg	5.81%	28189.13
Soft Plastic	0.722kg	0.64%	3105.17
Recyclable Plastic	6.22kg	5.48%	26588.03
Cardboard	3.96kg	3.49%	16932.89
Paper	16.37kg	14.43%	70011.91
Organic Waste	38.45kg	33.51%	162584.82
Totals	113.41kg	100.00%	485183.00

Source: EPT waste audit data courtesy of Paul Richard, EPT program.

Figure 21 outlines the method used to calculate the footprint of transporting the general waste to the landfill, which follows that in Acosta and Moore, 2009. Further details are in Appendix 7.1.4, along with estimates of the footprint to operate the landfill and the footprint to transport recyclable materials to their depot.

Figure 21: Calculation of Footprint of Transport to Landfill

Variables	Values Used
Total General Waste	176703.65kg (176.70365t)
Heavy Duty Vehicle Emission Rate	0.00018tCO2e/Km
Distance to Closest Landfill in Metro Vancouver	28.30 Km
Global Ecological Footprint Factor	0.28 gha/tCO2
Total Ecological Footprint	3.21gha

The same procedure was used to calculate the footprint of transporting materials that are recycled to the recycling depot. Finally, the footprint of the landfill itself was calculated (energy used for operations and release of methane from decomposition) using conversion rates from Barrett (2012) as also outlined in Appendix 7.1.4.

The total footprint of recycled material and waste was estimated to be 58 gha, and of waste that is landfilled 78 gha. Together they represent 1.3% of the KPU footprint.

3.3.5 Computers and Telecommunications Equipment

Data on the numbers of computers and other telecommunications equipment were provided by the IET department. We were unable to obtain any reliable conversion rates for physical units for these items so we used the input-output model made available by the Carnegie Mellon Life Cycle site to estimate the embodied energy and land associated with manufacturing. Operating energy for computers was also reported by IT, and the total footprint for this component is the sum of these two stages. It does not include the recycling or disposal stage of the equipment.

To use the Carnegie Mellon tool, the physical numbers of computers and other equipment had to be expressed in dollars. This was done by calculating the average price of equivalent items on the Best Buy website. The IET department provided the average service lives for some of this this equipment, and this was used to calculate one year's cost. This total was entered under the "Computers and peripherals" sector of the Carnegie Mellon model, and the resulting greenhouse gasses, energy used and land areas associated with the manufacturing of this value of production by this sector are reported in Figure 22.[35]

Figure 22: Carnegie Mellon Estimates of Emissions and Land Area Associated with Manufacturing Computers and Telecommunications Equipment.

Equipment type	Number of units	Annual cost (one year depreciation) ($)	Greenhouse gas (tCO_2e)	Energy (Tj)	Land use (Ha/a)	Footprint area (Gha/a)
Computers	3512	571,470	162	24	110	155.55
Printers	716	109,073	31	.47	2	118.68
Network	7426	206,621	56.6	.88	4	19.85
Telecom	1299	19,582	41.7	.63	2	13.68
Total			291.3	4.41	118	307.8

Source: Calculated from KPU data courtesy of Sukey Samra and calculator tool from Carnegie Mellon University Green Design Institute. (2014) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2002 (428 sectors) Producer model [Internet], Available from: <http://www.eiolca.net/> [Accessed 15 Nov, 2014], for more details see Appendix 7.1.5

In addition to the manufacturing footprint, the energy used to operate computers and other equipment was calculated from data on energy use provided by the IET department (see Figure 23 below). The total computer and peripherals footprint to both manufacture and operating this equipment was 308 gha, or 3.0% of the KPU total. It does not include the final stage in the life cycle of this equipment, recycling and disposal.

Figure 23: Footprint of Operating Electricity, Computers

Operating energy footprint of KPU computers							
	No. units	kWh/year/unit	$/day/unit	Source	kWh/year	$/year	Gha
Lab compute	30	284	26.75	PC rate	8,520	803	0.362
Student PC	537	284	26.75	PC rate	152,508	14,366	6.482
Staff PC	550	284	26.75	See below	156,200	14,714	6.639
Staff laptop	464	142	13.38	Half PC rate	65,888	6,207	2.800
Thin Clients	1600	132	12.43	See below	211,200	19,895	8.976
Macs	146	284	26.75	PC rate	41,464	3,906	1.762
Servers (phy	185	284	26.75	PC rate	52,540	4,949	2.233
Total comput	3512				688,320	64,840	29.2536

Source: Number of units provided by and electricity consumption estimated from data courtesy of Sukey Samra.[36]

3.3.6 Auto and Transit Transportation

As reported in Figure 24 below, the auto transportation component of the KPU footprint was estimated to be 3199 gha, or 31.1% of the KPU total, while that for transit was 246 gha or 2.4% of the total.

Figure 24: KPU Auto and Transit Footprint

Auto transportation											
	Category	Unit	Data	Source		Data		Conversion	Source	Gha	
	Auto parking	m2	31,700	See Campus area a		3.17		2.64000	Equivalence facto	8.37	
	Auto student	km	34,609,273	Home postal codes	1000	34609		0.000069	Barrett, p. 49 rep	2,401.88	
	Auto student passenger or dr	km	-	Home postal codes	1000	0		0.000069	Barrett, p. 49 rep	0.00	
	Auto faculty alone	km	4,105,629	Home postal codes	1000	4106		0.000069	Barrett, p. 49 rep	284.93	
	Auto staff alone	km	3,694,787	Home postal codes	1000	3695		0.000069	Barrett, p. 49 rep	256.42	
	Employee milage	$	222,086	Estimates using m	1000	222		0.000069	Barrett, p. 49 rep	15.41	
	Employee car rental	$	8,348	Estimates using m	1000	8		0.000069	Barrett, p. 49 rep	0.58	
	Car2Go	km			1000	0		0.000023	One third of the a	0.00	
	Auto share of BC roads	ha	174	Taken from 2008 EF			See Moore 1	1.33000	Forest land conve	231.42	
	What if?										
	(Auto total), includes parking area										3199.0
Transit transportation											
	Student transit	km	7,716,254	Home postal codes				0.00003	Chambers	231.49	
	Faculty transit	km	287,458	Home postal codes				0.00003	Chambers	8.62	
	Staff transit	km	116,789	Home postal codes				0.00003	Chambers	3.50	
	KPU Shuttle	pass km	11,820	600 passenger trip				0.00006	twide the above	0.73	
	Transit share of BC roads	ha	1.74	Guestimated as au				1.20000		2.09	
	What if?										
	(Transit total)										246.4

Source: KPU 2014 Ecological Footprint calculator, See below for details

In order to estimate the distance travelled to and from campus by students and staff, 6 digit home postal codes for students, faculty and staff in Fall 2013 were obtained from KPU Institutional Analysis Department. The latitude/longitude coordinates for the postal code centroids were obtained from the Platinum Postal Codes Suite 2006 on the Equinox data base[37] and converted to UTM coordinates.[38] The distance from home postal code to home campus was then calculated as the sum of the difference in easting and northing of the UTM coordinates.[39]

For 2,379 of 14,593 of the postal code-campus combinations, the distances between the postal codes and the home campus had previously been derived by the Geography 2250 class in 2013. This analysis used Google Maps to estimate distances, and it was found that this method was, on average 0.5 km more than the corresponding distance calculated from the UTM coordinates. The former distances were used when available and when not, the latter.

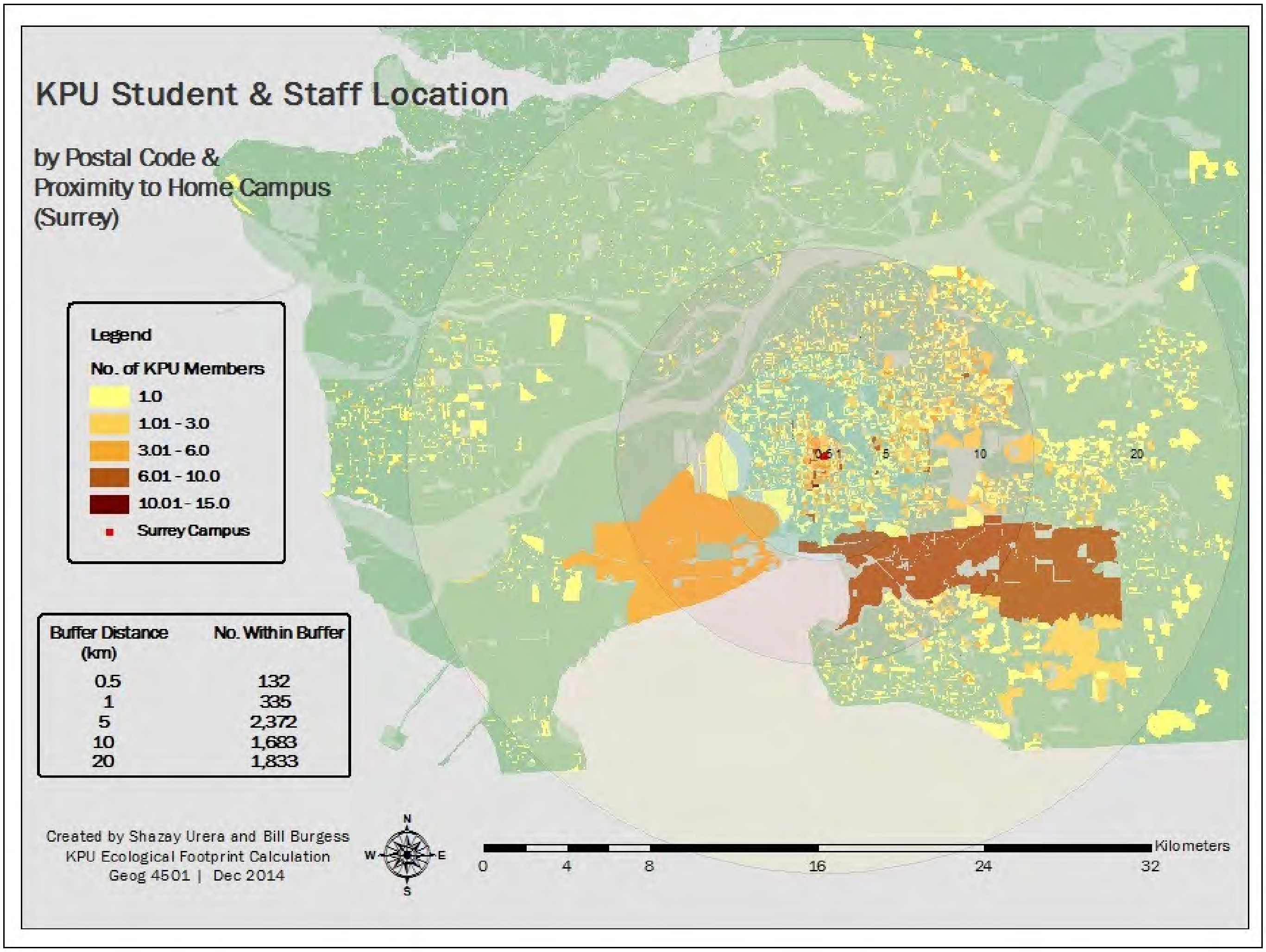
Frequency and mode of travel were taken from the 2014 Transportation Survey commissioned by the KSA. The 212 faculty members surveyed reported they travelled to campus on average 3.7 times per week, with 4% walking or biking, 80% driving and 16% using transit. For the 230 staff members surveyed, the average number of trips per week to campus was 4.7, with 5% walked or biked, 11% travelling by transit and 84% driving. The 2,193 students surveyed reported travelling to campus an average of 3.1 times per week, with 10% walking or biking, 40% travelling by transit and 50% driving.[40] Faculty were assumed to travel to campus 36 weeks per year, staff 46 weeks per year. The number of weekly trips by students was adjusted to reflect the relative enrollment numbers by semester - fall 40.2%, spring 38.5% and summer 21.3%, according to enrollment data from the Institutional Analysis department.

The conversion rate for auto transportation was taken from Barrett, 2012[41] and for transit from Chambers, 2000.[42] The area of campus parking lots was included in the transportation footprint, along with the estimated share of the area of roads in BC pro-rated by the distances travelled to and from campus relative to all vehicle trips in BC.[43]

It is evident that improving transit access to KPU campuses would be an important way to both meet the transportation needs of students and staff and reduce the overall KPU footprint. In order to identify obstacles to improvements in access to campus, basic information on where students and staff live relative to the campuses is needed.

Figure 25 below displays the home postal code of students and staff for whom Surrey was the home campus in the fall of 2013.[44] It should be noted that postal codes vary a great deal in area covered (e.g., the largely rural areas in Delta and South Langley cover very large areas; this should be taken into account when registering the number of students and staff by postal code).[45]

Figure 25: Home Postal Codes of Students and Staff, Surrey Home Campus:



To illustrate accessibility to KPU campuses by transit, Figure 26 depicts the areas within the Lower Mainland that are within 500 meters of a transit stop, and Figure 27 is an enlargement of the same for the Surrey area. Finally, Figure 28 reports the numbers of students, faculty and staff who live in postal codes whose centroid is within 500 metres of a transit stop.[46] A distance of 500 metres is assumed by Translink to represent accessible transit.

As can be seen, in municipalities like Abbotsford, Fort Langley and Mission, less than 10% of the KPU population live within 500 metres of a transit stop. In Surrey, 33% of the KPU population live within 500 metres of a transit stop, 37% in Langley and 36% in Richmond. Issues like the frequency of transit service, the hours of service, and the number of connections are obviously also important, but the above data provide a beginning point to identify locations needing better transit service.

Figure 26: Areas Within 500 Meters of a Transit Stop, Lower Mainland

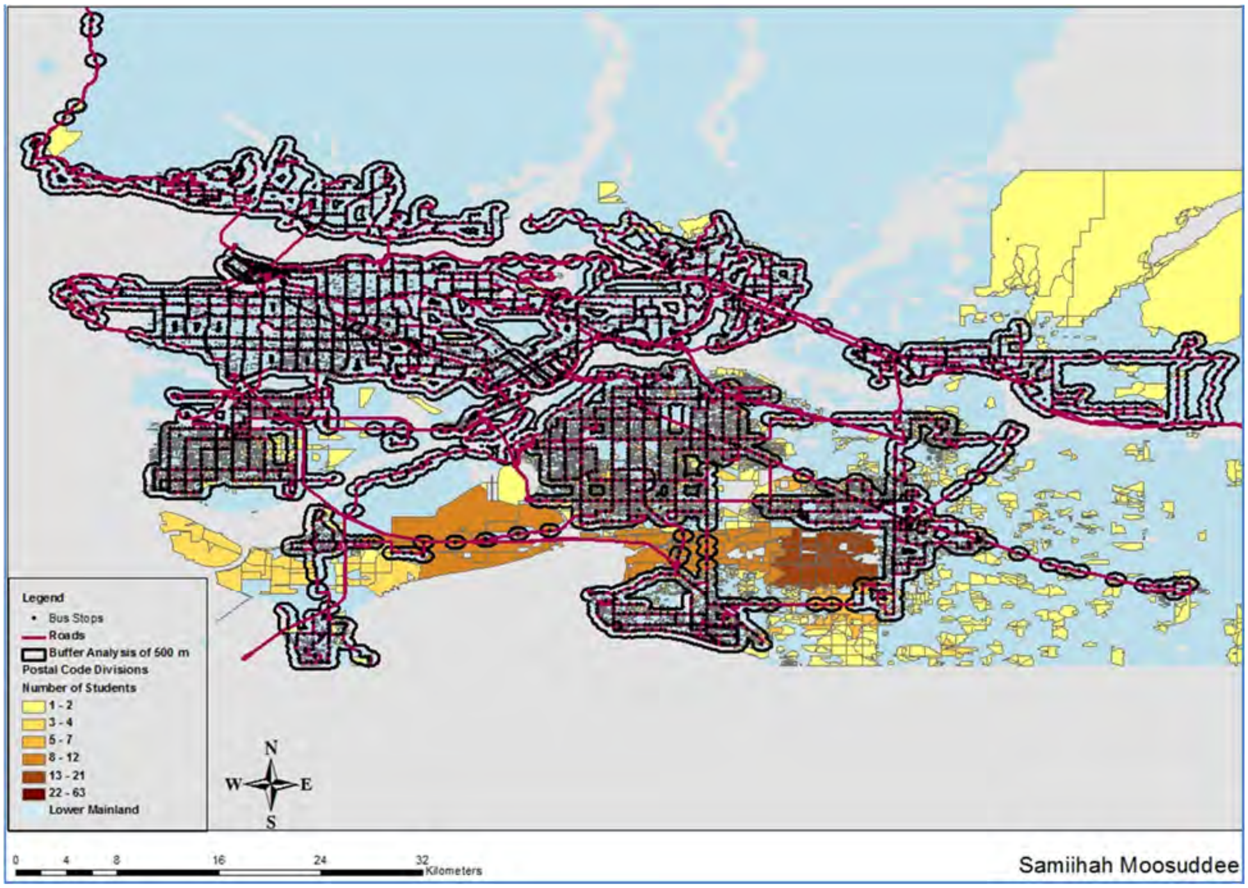


Figure 27: Area Within 500 Meters of a Transit Stop, Surrey

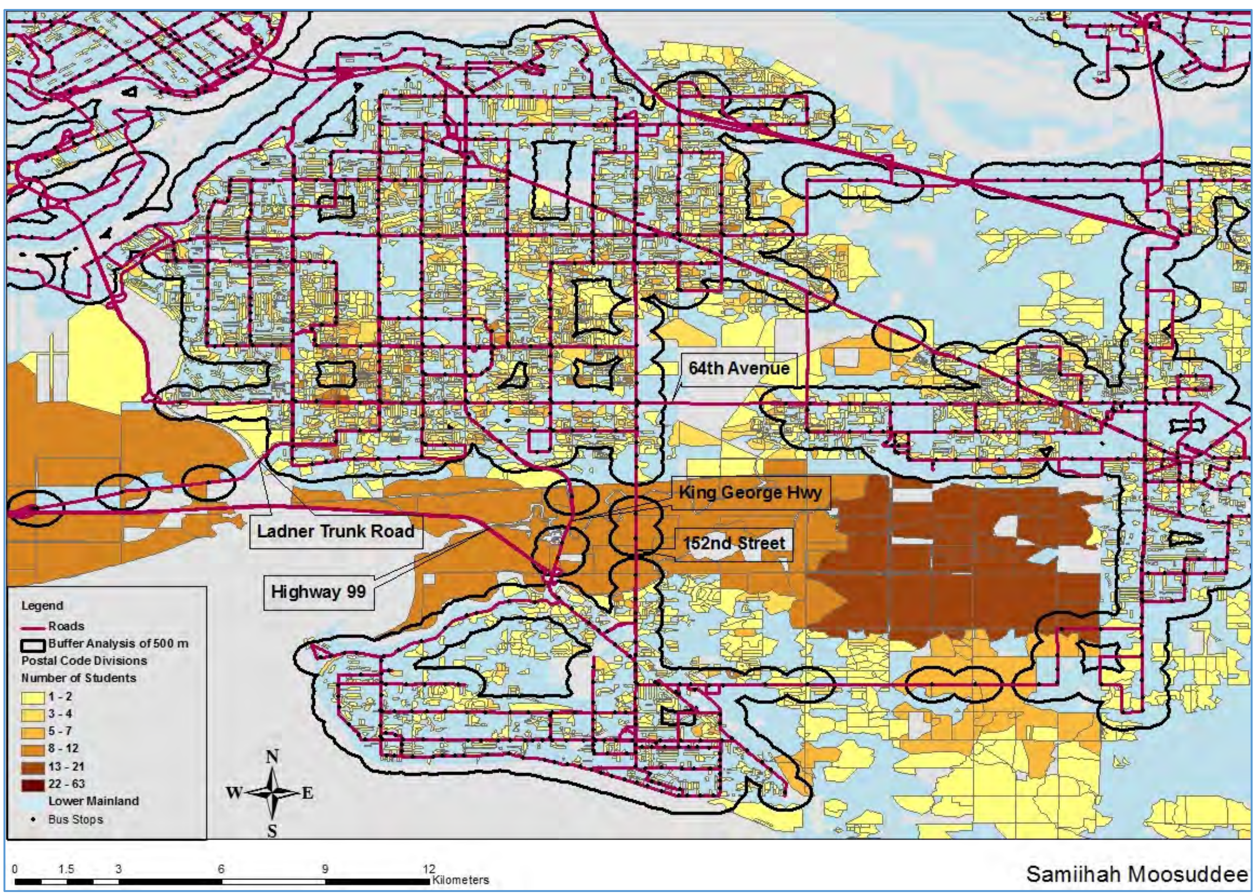


Figure 28: Numbers of Students, Faculty and Staff Living in Postal Codes with Centroids Within 500 Metres of a Transit Stop

City of Residence	Total KPU students and employees in Cities	Total KPU students and employees in city living within 500 m transit buffers	Percentageof KPU Students and Employeesin city living within 500 m transit buffers
Abbotsford	253	3	1.2
Aldergrove	82	26	31.7
Anmore	5	3	60
Belcara	2	1	50
Bowen Island	1	1	100
Burnaby	661	339	51.3
Cloverdale	6	4	66.7
Coquitlam	206	138	67
Delta	1707	737	43.2
Dewdney	1	1	100
Fort Langley	31	2	6.5
Ladner	15	8	53.3
Langley	1500	553	36.9
Maple Ridge	215	128	59.5
Mission	74	1	1.4
New Westminster	246	135	54.9
North Delta	34	13	38.2
North Vancouver	116	82	70.7
Pitt Meadows	38	21	55.3
Port Coquitlam	112	80	71.4
Port Moody	46	31	67.4
Richmond	3381	1227	36.3
South Surrey	11	4	36.4
Surrey	9459	3139	33.2
Tsawwassen	10	6	60
Vancouver	1765	1120	63.5
West Vancouver	44	27	61.4
White Rock	220	131	59.5

3.3.7 Air travel

Air transportation is estimated to account for 3326 gha, or 32.3% of the total KPU footprint, the largest single component. Of this total, 3002 gha represents the footprint of a questimated one return flight to Europe, Asia or South America per year by each of KPU's 1,962 international students. Data for business and conference travel by KPU employees were provided by the Finance Department and the flight portion of these submitted expenses was estimated. The conversion rates for air travel were taken from Chambers, 2000. See Appendix 7.1.6 for more details.

The above estimate for international students is obviously crude, but it is clear this component is very significant. If international student air travel is considered part of the KPU footprint in future calculation more effort should be expended to accurately quantify its contribution.

3.3.8 Vending Machines

Vending machines for sweet and salty snacks are operated by Ryan Vending, Coca Cola operates the machines that dispense bottled and canned drinks, and the KSA operates water dispensing machines. Each group provided the data on product volumes dispensed from their machines.

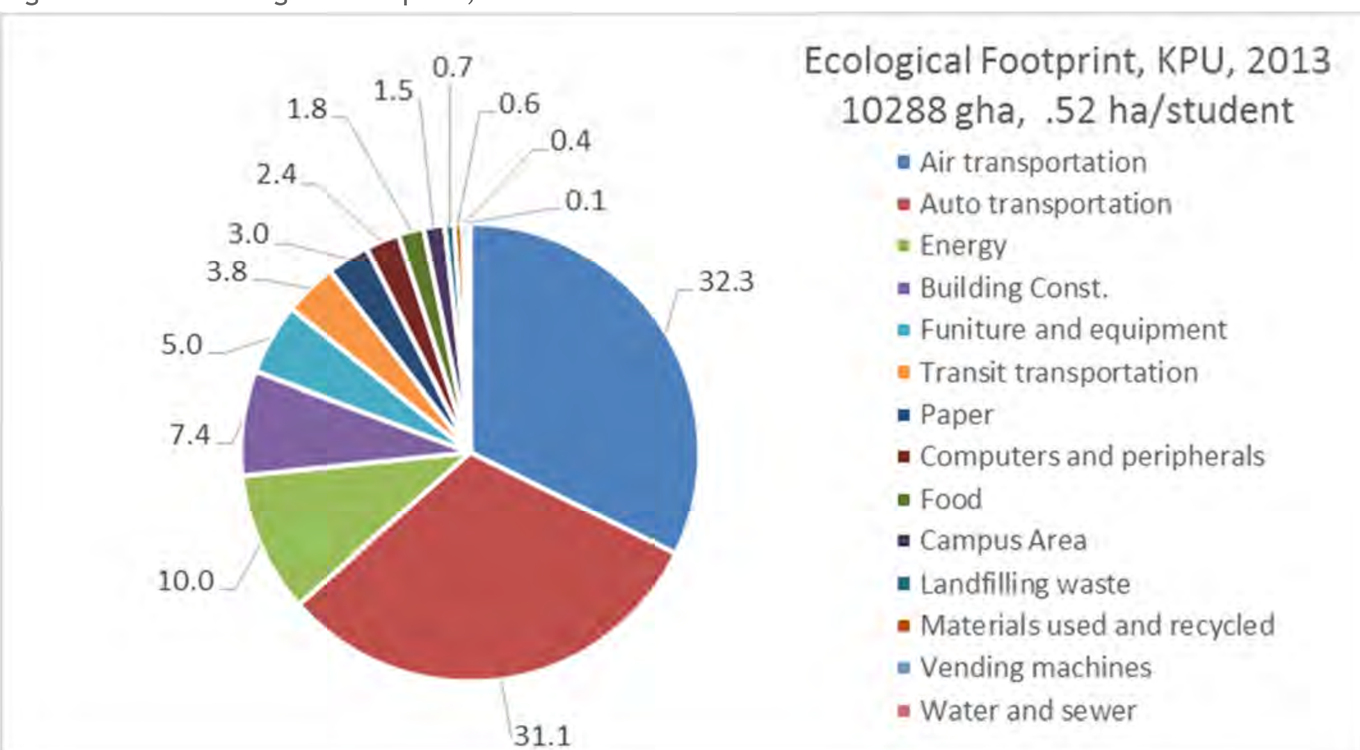
Footprints were calculated for the snack and drink and drink products using conversion rates from Kissinger, 2013. The footprint of the energy required to deliver recyclable plastic and aluminum to the recycle depot was calculated, along with the footprint of the waste going to landfill. The Carnegie Mellon tool was used to calculate the embodied energy and land needed to manufacture the vending machines, and the footprint of the electricity to operate the machines was estimated. See Appendix 7.1.7 for more details. The total resulting footprint was 44.5 gha, or 0.4% of the KPU total.[47]

5.0 Summary, Conclusions and Recommendations

5.1 Summary of Results

Figure 29 reports the total KPU footprint. [48] The largest contributors were air flights by staff and international students (32%), auto transportation (31%), electricity and gas energy (10%), and this year's share of the construction of the buildings (7%).

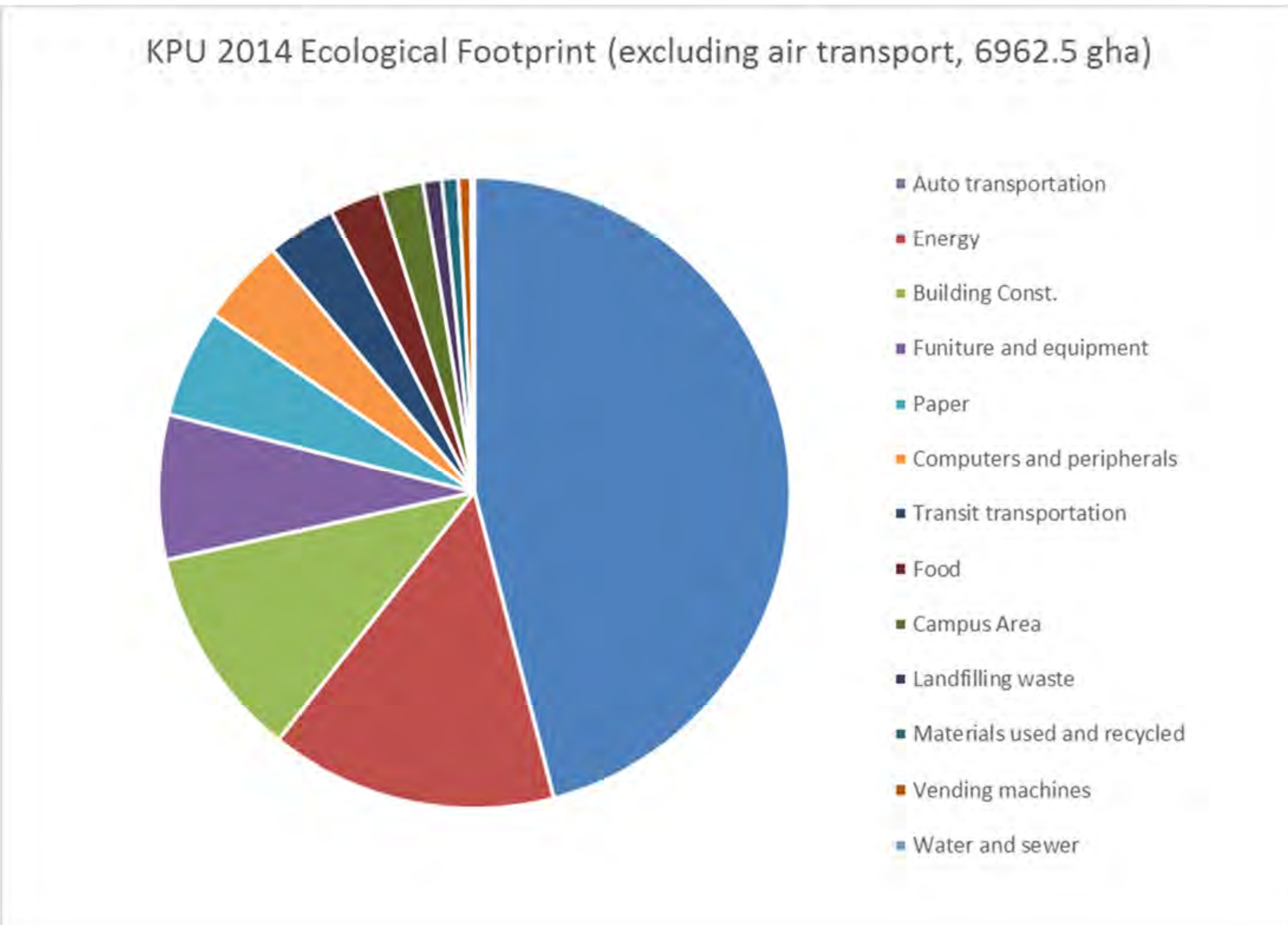
Figure 29: KPU Ecological Footprint, 2013



These footprint areas should be understood as accurate to about an order of magnitude. While we can have confidence in the data reported on energy and gas usage, in most other areas it is hard to evaluate the reliability of the data reported. As in all cases of the component approach to calculating ecological footprints, there is considerable uncertainty regarding the conversion rates used to derive the global hectares of land required to produce the resources or absorb the wastes. Several different conversion rates were employed, and not all component footprints address all stages of the life cycle of the product or process in question.

However, the general pattern is probably reasonably accurate. It is clear that transportation stands out as a major contributor to the overall footprint. If we exclude the one return flight per year by international students, auto transportation in particular begs attention by contributing 46% of the total annual footprint, more than three times that of the second largest category, gas and electricity energy (see Figure 30 below). The footprints recorded here for food and waste are not large in relative terms, but they are notable because they can probably be reduced more easily than for some other areas.

Figure 30: KPU Footprint, Excluding Air Transportation Component



5.2 Conclusions

The main conclusion of this study is that the calculation of KPU's ecological footprint is a worthwhile exercise for both education regarding sustainability issues and to inform institutional policy. This 'first cut' effort should be refined and extended. More complete and consistent data from the various departments and other campus bodies, and more up-to-date sources of and otherwise standardized conversion rates that include all stage of the life cycle would make this possible.

5.3 Policy Recommendations

The following are recommendations to KPU from this study by the members of the Fall 2014 Geography 4501 class:

1. General KPU Sustainability Policy

Sustainability should be a higher and more visible priority in all KPU activities as a matter of institutional policy. This should include aspects of curriculum development, campus operations, and KPU's role in the community. Sustainability policy should, in principle, reflect the science that underpins the 'strong' sustainability approach rather than being limited to those measures that are consistent with the status quo, whether individual-behavioral or political-economic in nature.

KPU should commit a portion of their budget to install/host/promote demonstration projects for alternative energy generation on campuses; for example, solar, wind, geothermal and to promote a reduction of energy use overall.

2. Sustainability Curricula

KPU should consciously develop sustainability as an important aspect of its polytechnic mandate, including by investing in demonstration projects and new programs oriented to knowledge and training for sustainability. All KPU programs should require that students take one course with substantial 'sustainability' content. An interdisciplinary first year course should be developed for this purpose, or departments or faculties could offer a version tailored to their particular programs.

3. Ecological Footprint Calculation

As KPU's energy conservation measures have demonstrated, "you can't manage what you don't measure." The KPU ecological footprint should be calculated annually as one metric of 'strong' sustainability, using a methodology that is comparable over time. A list of the required data should be distributed to all KPU departments so this information can be made available in a timely and consistent fashion.

4. Transportation

Providing better access and reducing the environmental impact of transportation to, from and between campuses should be adopted as the current priority measure related to KPU's sustainability initiatives.

KPU should include questions about trip origin, mode, time and frequency in the annual transportation survey of students and staff to provide the data needed to inform possible improvements.

KPU should continue to be a major public advocate of better transit in the South-of-Fraser region. It should continue to be actively involved in the discussion of new transit infrastructure in order to maximize improvements in transit, pedestrian and bicycle access to KPU campuses. KPU should feature information on transit access when recruiting students.

KPU should discourage flying by employees on KPU business when there are other feasible options, e.g. teleconferencing, fewer trips that address more business, etc.

5. Waste

KPU should institute more separation of waste (e.g., the 5 bin system) and should have an organic waste composing facility on one or more campuses for KPU's organic waste.

6. Food Services

As part of a broader effort to educate the campus community about sustainability issues, the food service operators on campus should report the environmental impact of their menus and institute practices like "Meatless Monday".

Food service operators should switch to local ingredients when possible to reduce 'food miles' and otherwise promote more sustainable agriculture.

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7.0 Appendixes

7.1 Calculations

7.1.1 Campus Area, Buildings and Furniture

Campus area:
-Total of 61.7 h (from KPU Site Plans), of which .34 h is forest and 3.17 h parking lots (calculated using Google Earth).

- .34 h* 1.33 forest equivalence factor = .45 gha deducted from campus area component
- 3.17 h * 2.64 cropland equivalence factor = 8.35 gha attributed to auto transportation

61.7* 2.64 cropland factor = 162.888 gha - (.45gha + 8.35gha) = 153.7gha

Buildings and major renovations:
-2013 amortization amount for buildings and major renovations $mil 6.121 (KPU Financial Statements 2013-14, p. 15; buildings amortized over 40 years, major renovations over 10 years)
-From Carnegie Mellon Life Cycle Tool: (Sector - Construction/Non-residential Commercial, Health Care and Education Structures, No 230101, US 2002 (428 sectors) Producer model, http://www.eiolca.net/):

-GG emissions: 3,610 tCO2e
-Land: .516h

- 3610 tCO2e - 25% absorbed by oceans = 2707.5 tCO2e * .28 gha/tCO2e = 758.1 gha
-.516 h*1.33 forest equivalence factor = .69 gha

Furniture and equipment:
-2013 amortization amount for buildings and fixed assets: $mil 3.806 (KPU Financial Statements 2013-14, p. 15; furniture amortized over 5 years)
-From Carnegie Mellon Life Cycle Tool: (Sector - Furniture/Office furniture manufacturing, No 33721A, US 2002 (428 sectors) Producer model, http://www.eiolca.net/):

-GG emissions:: 3806 tCO2e
-Land: .95h

- 2460 tCO2e - 25% absorbed by oceans = 1845tCO2e * .28 gha/tCO2e = 516.6 gha
-.95 h*1.33 forest equivalence factor = 1.26 gha

7.1.2 Energy

-2013 electricity consumption 11.3578 gwh (Energy Consumption Records 2013, p. 3)

BC Hydro source	*%***	*Gwh*	*Conversion rate (gha/gwh)*	*Source*	*EF (gha)*
large dam hydro	70.8	8.004	42.5	Chambers, p. 83*	323.49
thermal (gas)	26.01	2.854	94.0	Chambers, p. 83*	262.73
biogas, municipal, non-storage hydro	2.97	.3373	36.5	Chambers, p. 83*	12.31
				[* average of values reported]	

** estimated from BC Hydro, 2011, BC Hydro Annual Report 2011, Vancouver: BC Hydro, p. 34, 88, http://www.bchydro.com/planning_regulatory/acquiring_power/how_power_is_acquired.html, http://www.bchydro.com/energy_in_bc/our_system/generation.html , the breakdown of IPP power from http://www.bchydro.com/etc/medialib/internet/documents/planning_regulatory/acquiring_power/2011q4/20111001_ipp_supply1.Par.0001.File.20111001-IPP-Supply-List-In-Operation.pdf, imports and exports from http://www.bcstats.gov.bc.ca/data/bus_stat/busind/trade/trade-elec.asp. The calculation assumes that imported electricity is thermal (gas) generated. The thermal share is higher than reported by BC Hydro, possibly because they do not seem to include imports in their calculation.Non-storage hydro, biogas and municipal waste treated as the same.

-less the estimated electricity reported for computers (.688320 gwa) and vending machines (.006927 gwa), see below .688343 55.6 w. ave. of above 38.30
=Total EF of electricity component 593.61 gha

KPU vehicle gas:
-litres of fuel used 7,141 (Facilities Dept, from SMARTOOL report to BC government)
- fuel consumption rate of 10l/100 km assumed; one passenger
-.000071gha/passenger km calculated from Chambers, 2000, p. 74 report of gha rate of .49 for petrol use per 10,000 pass km and .22 for manufacture and maintenance per 10,000 passenger km ((.49+.22)/10000=.000071), though this appears to only represent the embodied energy, not the land area required for material inputs and manufacturing and for disposal. ,
-7141 l *10 km/l=71410 km, 10000 pass/km = 7.14 *.000071 gha/10,000 pass km = .51 gha.

7.1.3.Paper

-KPU office fine paper: Data courtesy of the Facilities Dept. (from SMARTTool report at https://www.wheregreenideaswork.gov.bc.ca/,art/aspx?report=Unit23&reportType…). 18,920 packages of 8.5*11 paper, 150 packages of 8.5*14 paper and 550 packages of 11*17 paper, all 20 lb and 30% post-consumer recycled fibre. 8.5*11 reams each weighs 5 lbs because the area for which the basis weight of 20 lbs is defined is 17*22 which 4 times 8.5*11, and 1lb = 0.453592 kg. Recycled proportion of 30% an estimate. The conversion rate is an average of the fine paper rates in Kissinger, p. 1967.

KPU Print Shop fine paper: Data is for 2011, as the 2013 data was not available, but the print Shop Manager Sean Kheler confirmed that there has been little change over this period. In 2011 he reported 167,568.48 pounds of paper, of which 35,271 pounds was recycled fibre = 21.05%. The conversion rate used is an average of the fine paper rates in Kissinger, p. 1967.

KPU washroom paper: The data for toilet paper and paper towels was compiled from the Unisource Customer Velocity Report, courtesy of the Finance Dept. The product code was looked up on the Unisource site http://www.unisource.ca/unisource/en/uni_products/ to confirm the product type was paper towels or toillet paper and to obtain the weight per unit. The data was for the first 10 months of 2014, so the totals were multiplied by 12/10 for an annual total. The recycled fibrer rate was calculated from data for 2011 courtesy of KPU Purchasing and http://productcatalog.gp.com/. The conversion rates used was the average value for newsprint in Kissinger, page 1967.

KSA, KFA and Library: Data for the KSA is from 2011 courtesy of Kari Michaels, and for the KFA courtesy of Kyla Rand. The Library reported acquiring 5400 books and the weight of their paper was calculated on the basis of the 1.37 lbs that Better Book Worlds reports is the average weight of a discarded book. The conversion rates used was the average value for commercial paper in Kissinger, page 1967.

7.1.4 Waste

The data resources used were from Kwantlen Polytechnic University’s Environmental Protection Technician program’s 2012 Waste Audit Report and the 2013 Waste Audit Report. The 2012 Waste Audit Report was done on November 15th, 2012 for Langley campus, and has a breakdown, both recyclable and not, of wastes similar to what data categories were laid out for the calculations of the Ecological Footprint of KPU. These categories included: garbage, non-recyclable plastics, recyclable plastics, cardboard, soft plastics, paper and organic waste.

The data for Langley campus was projected to all campuses on the basis of the relative number of students, as reported below.

Percentage Distribution of Garbage for each Kwantlen Campus, Determined by EPT student survey:

	Number of Students Enrolled Per Semester Per Campus		
Campus	Spring 2013	Fall 2012	Summer 2012
Surrey	8179	8237	4911
Langley	2871	2934	529
Richmond	5577	5873	2910
Cloverdale	959	720	286

	Weight of Garbage Produced Per Semester (kg)			
Campus	Spring	Fall	Summer	Year-round
Surrey	22,165	22,322	13,309	57,796
Langley	7,780	7,951	1,434	17,165
Richmond	15,114	15,916	7,886	38,916
Cloverdale	2,599	1,951	775	5,325
KPU	47,658	48,140	23,404	119,202

Campus	Weight of Garbage Produced Yearly (kg)	Percentage of Total KPU-Wide Garbage Produced (%)
Surrey	57,796	48
Langley	17,165	14
Richmond	38,915	33
Cloverdale	5,325	5

The transportation footprint for disposing of these projected total amounts of KPU waste by type were then calculated on the basis of the distance to the nearest landfill; note this does not include the area of the landfill in question or the emissions from the landfill itself:

Footprint calculations for disposing of Kwantlen's waste:

Waste type	Soft Plastic Waste to Landfill	Recyclable Plastic Waste to Landfill	Cardboard Waste to Landfill	Organic Waste to Landfill
Total Waste	3105.17 kg	26588.03 kg	16932.89kg	162584.82 kg
Heavy Duty Vehicle Emission Rate	0.00018tCO2e/km	0.00018tCO2e/Km	0.00018tCO2e/k	0.00018tCO2e/k
Distance to Closest Lanfill in Metro	28.30 Km	28.30 km	28.30 km	28.30 km
Global Ecological Footprint Factor	0.28 gha/tCO2	0.28 gha/tCO2	0.28 gha/tCO2	0.28 gha/tCO2
Total Ecological Footprint	0.056 ha	0.48 ha	0.308 ha	2.96 ha

7.2.5 Computer and other equipment

The table below reports the inventory of equipment provided by the KPU IET department and the manufacturing footprint as calculated by the Carnegie Mellon tool.

Computer and telecomunication KPU hardware inventory						Manufacturing footprint according to Carnegie Mellon life cycle a				
Category	Item	# of Items	Service life	price	Cost	Economic sector	Greenhouse Gasses T CO2e	Energy TJ	Transport - Air tonnes-	Land use
Units		no.	years	$/unit	$/year		tCO2e	Tj	km	ha
Computers	Lab compute	30	3.5	946.99	8,117					
	Student PC	537	3.5	859.99	131,947		0.07	0.001	1.62	0
	Staff PC	550	4	859.99	118,249		0.061	0.001	1.41	0
	Staff laptop	464	3.5	777.30	103,048		0.063	0.001	1.46	0
	Thin Clients	1600	7	388.65	88,834					
	Macs	146	3.5	1707.34	71,220		0.138	0.002	3.2	0
	Servers (phy	185	3.5	946.99	50,055					
	Total compu	3512			571,470	334111 El	162	2.44		110
Printers	MFD printers	108	3.5	716.36	22,105					
	Local printer	250	3.5	716.36	51,169					
	Printer ink, e	358		100.00	35,800					
	Total printer	716			109,073	334111 El	31	0.467		2
Network harc	Edge switche	259	3.5	25.00	1,850					
	Wifi access p	375	3.5	100.00	10,714					
	Network port	6792	3.5	100.00	194,057					
	Total Networ	7426			206,621	334111: El	56.6	0.882		4
Telecommunication										
	Servers - tele	4	3.5	946.99	1,082					
	Phone sets	1295	3.5	50.00	18,500					
	Total telecon	1299			19,582	517000 Te	41.7	0.628		2
TOTAL ALL							291.3	4.417		118

Source: Number of items courtesy of Sukey Samra, KPU IET Dept., service life a questimate, prices from similar units at Best Buy. Manufacturing footprint from Carnegie Mellon University Green Design Institute. (2014) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2002 (428 sectors) Producer model [Internet], Available from: <http://www.eiolca.net/> [Accessed 15 Nov, 2014]

7.1.6 Auto and transit transportation

The estimates for distances travelled are described in the text. The conversion rates used are from Barrett, 2012, and Chambers, 2000. The KPU share of the roads was estimated on the basis of 62% of Kwantlen pop using cars, and their Kwantlen use of the car being 50% of total use, times the per car road area in BC calculated from total road area in BC and total number of cars in BC from Moore, 2013, p. 137, and that the forest land converted to roads had 133% bioproductivity of a world hectare.

7.1.7 Vending Machines:

Weight for sweet and salty snacks vending machines (1 year):

Langley Campus: approximately 19,000 units
Surrey Campus: approximately 31,500 units

Cloverdale Campus: approximately 4,000 units
Richmond Campus: approximately 13,000 units (Average weight of wrapper = 2 g)

Langley Campus: 19,000 units x 2 g = 38,000 g = 38 kg
Surrey Campus: 31,500 units x 2 g = 63,000 g = 63 kg
Cloverdale Campus: 4,000 units x 2 g = 8,000 g = 8 kg
Richmond Campus: 13,000 units x 2 g = 26,000 g = 26 kg

38 kg + 63 kg + 8 kg + 26 kg = 135 kg = 0.135 tonnes/year (wrappers)

Electricity for sweet and salty snacks vending machines ($/year):

Langley: 4 snack machines x 15.07 cents/day = 60.26 cents/day = 21,994.90 cents/year = $219.95/year
Surrey: 7 snack machines x 15.07 cents/day = 150.49 cents/day = 54,928.85 cents/year = $549.29/year
Cloverdale: 1 snack machine x 15.07 cents/day = 15.07 cents/day = 5,500.55 cents/year = $55.01/year
Richmond: 3 snack machines x 15.07 cents/day = 45.21 cents/day = 16,501.65 cents/year = $165.02/year

$219.95 + $549.29 + $55.01 + $165.02 = $989.27/year

(Information received from Gary Lambert, Ryan Vending Ltd.)
Weight/Volume for Coca Cola vending machines (1 year):

72 cases of cans (24 units each) = 1,728
1,672 cases of bottles (24 units each) = 40,128
Cans: 1,728 units x 14 g = 24,192 g = 24.192 kg
Bottles: 40,128 units x 59 g = 2,367,552 g = 2,367.552 kg

24.192 kg + 2,367.552 kg = 2,391.744 kg = 2.392 tonnes/year[49]

8.0 Endnotes

[1] Some also point to an ‘intermediate’ conceptualization of sustainability. Dependence on environmental services is acknowledged but it holds that capital and technology created by human societies can substantially replace natural capital and natural processes. Ambitious changes may be required (e.g., dedicating carbon resources to finance the transition to a non-carbon economy), but no full restructuring of the existing social and economic order (Rees, 2006).

[2] The EF excludes open oceans, less productive lands, allocation of land and habitat for other species, the global carbon budget, and multi-use land (Talberth and Venetoulis 2007). Net primary productivity (measure of carbon accumulation into plant biomass) is not taken into account, which could take place of equivalency factors (EQFs) for greater accuracy (Talberth and Venetoulis 2007). It does not measure issues such as quality of life for humans or other animals (Wackernagle 2000). Carbon sequestration is based on what forests are able to sequester (plus some by oceans), not the entire Earth’s surface. Thus, the EF is a generalization of reality, a simplification of nature, and intentionally underestimates impacts. One interesting extension of the basic ecological footprint model is the effort to convert it from a ‘static’ measure to a ‘dynamic’ measure by quantifying the effects over time of resource use and waste production in much the same way that climate models have been developed to predict the long term effects of greenhouse gases (see, e.g., Lenzen et al, Forecasting the Ecological Footprint of Nations: a blueprint for a dynamic approach, Stockholm Environmental Institute and University of York, 2007, http://www.isa.org.usyd.edu.au/publications/DEF.pdf).

[3] A variety of social, ecological, and economic indicators have been developed to measure a society’s well-being (Wackernagle 2000). Most are not standardized and vary throughout the different populations using them. Some are drawn from aggregate data such as CO2 emissions and concentrations, and while it is important to know the carbon emissions and concentration of an area, they do necessarily help understanding of their contribution to unsustainability or global warming (Wackernagle 2000).

The Natural Step has developed principles that can be followed to achieve sustainability. These principles are a framework for sustainability but they are not standardized. They do not get to the root causes of unsustainable behaviour, and are so detailed they may lead initiatives off track (Wackernagle 2000). The Environmental Space metric accounts for the amount of ecological capacity that is used by people as well as what can sustainably be used. This metric is specific to per capita expressions of sustainability. It has a set target of sustainability, which may be perceived as subjective, takes little account of differing ecological materials and is not very accessible or meaningful to the average person (Wackernagle 2000).

Almost all countries have legally mandated environmental impact assessments processes. When done correctly they can provide detailed and useful descriptions of possible ecological, social, and economic impacts of a particular industrial or infrastructure project. However, as with most other metrics they are not standardized, they are often detailed for popular purposes, and they usually fail to take into account cumulative effects (Wackernagle 2000). Life Cycle Analysis is a metric that studies the life cycle of a particular product, such as paper, from cradle to grave. It is often a very specific measurement that is not standardized. By itself it does not lead to much understanding by the average person (Wackernagle 2000).

[4] See http://www.footprintnetwork.org/en/index.php/GFN/

[v] The categories in this figure vary from those on the right used by the Global Footwork Network. There are good biological reasons for including an area for bioproductivity but it is not included in the GFN methodology in the interests of conservative estimation.

[6] See http://www.footprintnetwork.org/en/index.php/GFN/page/application_standards/ and http://www.footprintnetwork.org/images/uploads/Ecological_Footprint_Standards_2009.pdf

[7] Global Footprint Network, *Ecological Footprint Standards 2009*, p.4)

8 See “Life Cycle Assessment,” from United States Environmental Protection Agency. (2014). Life Cycle Assessment (LCA). [Sustainable Technology]. Retrieved from http://www.epa.gov/nrmrl/std/lca/lca.html.

[9] Chambers, N. Simmons, C. Wackernagel, M. (2000). Sharing Nature’s Interest. London, UK: Earthscan Publications Ltd.

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Barrett, John et al, 2012. A Material Flow Analysis and Ecological Footprint of York. Technical Report. Stockholm: Stockholm Environmental Institute, www.sei,se;
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Carnegie Mellon University Green Design Institute. (2014) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2002 (428 sectors) Producer model [Internet], Available from: <http://www.eiolca.net/> [Accessed 6 Dec, 2014]

[10] World Footprint Do we fit on the planet? (2014, October 30). Retrieved Dec. 16, 2014, from http://www.footprintnetwork.org/en/index.php/GFN/page/world_footprint/

[11]WWF. (2014). Canadians must choose environment and economy for strong future. Living Planet Report 2014. Retrieved from http://www.wwf.ca/newsroom/reports/living_planet_report_2014.cfm

[12] Deciles are one tenth, so the figure reports on the poorest 10% of families up to the richest 10% of families.

[13] MacKenzie et al, Size Matters: Canada's Ecological Footprint, by Income, Canadian Centre for Policy Alternatives, 2008. Note that this study divides the total Canadian footprint among all income groups and does not attempt to distinguish between footprints for food and shelter as opposed to bitumen extraction or military activities, for example.

[14] Moore, Jennie & Kissenger, Meidad & Rees, William E. (2013). An Urban Metabolism and Ecological Footprint Assessment of Metro Vancouver. *Journal of Environmental Management, 124.*

[15] Thompson Rivers University. (2012). *Thompson Rivers University Campus Sustainability Action Plan: Ecological Footprint Analysis and Steps Forward 2010-2012.*

[16] Acosta, Kerly, & Moore, Jenny. (2009). Creating an Ecological Footprint Assessment: Using Component and Compound Economic Input Output Methods. Retrieved from https://courses.kpu.ca/pluginfile.php/68613/mod_resource/content/3/bcit__ecofootprint__methods_final_report_.pdf

[17] Burgess, Bill and Jessica Lai, Ecological Footprint Analysis and Review, KPU, 2006, available at http://www.kpu.ca/sites/default/files/downloads/Ecological_Footprint_Study6847.pdf .

[18] Kwantlen Ecological Footprint Calculator 2012, Geography 4501 files.

[19] One unfortunate omission from the calculation is the KPU Bookstore.

[20] Campus and building areas reported on Facilities Dept. web site http://www.kpu.ca/sites/default/files/Facilities, while the area of parking lots and of forest area calculated by overlaying a grid on Google Map images of the campus areas.

[21] One tool to do so can be found at http://www.athenasmi.org/our-software-data/ecocalculator/

[22] Carnegie Mellon University Green Design Institute. (2014) Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2002 (428 sectors) Producer model [Internet], Available from: <http://www.eiolca.net/> [Accessed 6 Dec, 2014]

[23] KPU amortizes buildings over 40 years and major capital repairs over 10 years. While the average service life of buildings might be more than that we should recognize that the buildings are already well into a possible service life of 75 years so 40 years may be reasonable.

[24] Oceans absorb about 25% of atmospheric CO_2. The remaining 2,707 tCO_2e is absorbed by land.

[25] This total also reports other impacts including the volume of toxic releases, water withdrawals and distances travelled in the transportation sector that contributes to the construction sector in questions but these are not considered here.

[26] KPU amortizes furniture over 5 years. Another estimate of this amount is the $ 2.614 million for furniture and fixtures moved from expenses to capital in 2013, as reported by a Finance Department employee.

[27] As above, this assumes a 25% uptake of CO2 by oceans and the .28 gha/tCO2e is considered for the embodied energy, and the 1.33 forest land equivalence factor for the land area.

[28] See http://www.nrcan.gc.ca/energy/natural-gas/5641

[29] BC Hydro, 2011, BC Hydro Annual Report 2011, Vancouver: BC Hydro, p. 34, 88, http://www.bchydro.com/planning_regulatory/acquiring_power/how_power_is_acquired.html, http://www.bchydro.com/energy_in_bc/our_system/generation.html , the breakdown of IPP power from http://www.bchydro.com/etc/medialib/internet/documents/planning_regulatory/acquiring_power/2011q4/20111001_ipp_supply1.Par.0001.File.20111001-IPP-Supply-List-In-Operation.pdf, imports from http://www.bcstats.gov.bc.ca/data/bus_stat/busind/trade/trade-elec.asp. The calculation assumes that imports are all thermal (gas). It treats non-storage hydro, biogas and municipal waste as the same. The thermal share is higher than reported by BC Hydro, probably because they do not report the imports.

[30] The rate used by Acosta and Moore is lower, on p. 25 she reports that BC Hydro estimates 46.5 t C02e/ GWh (in BC Hydro Greenhouse Gas Report, March 2005), and it would take 13.04 gha to sequester I Gwh of BC Hydro power. Part of the difference may be the embodied energy and land for dams, roads and transmission infrastructure.

[31] This assumes the same sources of generation for BC Hydro as above for 2013. Electricity and gas in 1998 were 11.547,798 Kwh and 53,367Gj, and the building area was 72,464m^2 in 1998 compared to 98,068m^2 in 2013, according to Energy Consumption Records 2013, p. 6.

[32] 26.25 kg (recyclables) + 1.7 kg (paper cups) + 9.25 kg (to-go containers) + 16 kg (cardboard) = 53.2 kg/week = 0.0532 tonnes/week. It was assumed that the numbers are roughly the same for the fall and spring semesters, with summer total half of those in the fall and spring: 0.0532 tonnes/week x 52 weeks = 2.77 tonnes/year ÷ 3 semesters = 0.923 tonnes/semester; of which Summer semester = 0.923 tonnes ÷ 2 = 0.462 tonnes; 0.923 tonnes (Spring) + 0.462 tonnes (Summer) + 0.923 tonnes (Fall) = total of 2.308 tonnes/year

[33] For this methodology see the section for Waste.

[34] Produce is mostly vegetables but it include some fruit, which is ignored here. We assume that beef is produced on grazing land, which has a much lower equivalence factor to global hectares than does cropland.

[35] The conversion rate used for manufacturing emissions was.28 gha/tCO2e reported by Acosta and Moore, 2009, p. 17. No conversion rate was applied to the land areas.

[36] Electricity calculated from data courtesy of Sukey Samra comparing electricity consumption for 1600 PCs (1818Kwh/day*5days/week*50 weeks per year, with sleep mode and $171/day for 1600 units) versus 1600 Thin Clients (845 Kwh/day *5days/week*50 weeks per year, with sleep mode and $80/day for 1600 units). Gha rate the 42.5 gha/Gwh average for hydro reported by Chambers, 2000, p. 83. 1gwh=1,000,000 kwh.

[37] at http://equinox2.uwo.ca.ezproxy.kwantlen.ca:2080/dbtw-wpd/exec/dbtwpub.dll?QF0=AltTitle|Title|Subtitle|SeriesTitle|Filespecifics|PersAuthor|CorpAuthor|Acronym|Nation|Abstract|Codebook|SupplierTitle|Topic|VarName|QuestionPreface|QuestionText|VarNotes|FreqTable|VarUniverse|Varlist|VarLabel&QI0=postalcodes&TN=Equinox&RF=UserDisplayComboEN&QB0=AND&QF1=Recordtype&QB1=AND&QI1=file/variable&AC=QBE_QUERY .

[38] Using the calculator available at http://www.uwgb.edu/dutchs/UsefulData/HowUseExcel.HTM.

[39] There were 1042 postal code-campus combinations were no lat/long was available (in some cases the postal code may have been out of BC) in which case the average distance of 12.7 km was inputed.

[40] The KSA survey included a “mixed mode” category that was excluded from these results.

[41] P. 49. The rate for students sharing cars or being dropped off was assumed to be half that for single occupancy vehicles.

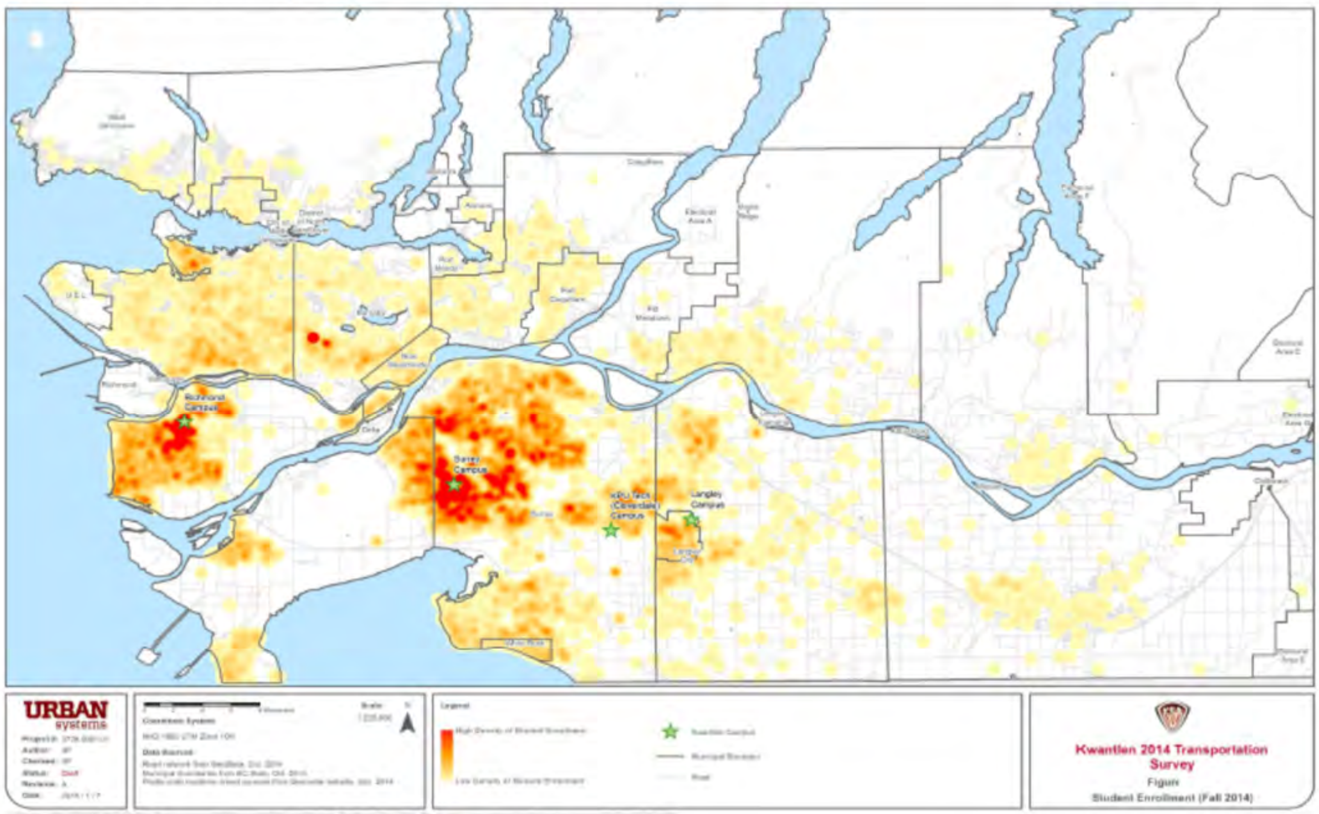
[42] Chambers reports a GHa rate of .49 for petrol and .22 for manufacture and maintenance per 10,000-passenger km, which appears to only represent the embodied energy. Chambers, 2000 reports a passenger car rate of .06 to .13 (USA) GHa per 1000 passenger km, this apparently includes manufacture, fuel and road use (UK).

[43] Estimated on the basis of 62% Kwantlen pop using cars, and their Kwantlen use of the car being 50% of total use. The per car road area in BC calculated from total road area in BC and total number of cars in BC. The conversion factor assumes that BC land used is forest land with 130% the bioproductivity of world hectares.

[44] Home postal codes were made available by the KPU Institutional Analysis Department, and map layers from the Platinum Postal Codes suite.

[45] A similar perspective, but for all KPU students is provided by this map from the KSA Transportation Survey:

Figure 10: Map of Kwantlen Students Residential Location (enrollment data)
Source: KPU Enrollment Postal Code Data (Provided by the KSA)



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[46] The use of centroids to represent postal codes means that some residents will be farther from the transit stop than 500 metres. However, most postal codes are quite small, e.g. less than 500 metres in diameter

[47] Ryan Vending and Coca Cola reported the number of machines, and the number for the KSA was estimated. Ryan Vending reported the service life of a vending machine and its annual electricity consumption, and these were projected to the other machines. The mid-range cost of a vending machine from Costco was used for the Carnegie Mellon calculations.

[48] The KPU bookstore was unfortunately omitted.

[49] Shannon Wise, Coca Cola.