Edmonton's Ecological Footprint

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About Mark Anielski

Mark Anielski is President of his family-owned corporation, Anielski Management Inc., based in Edmonton, Canada. Mark is an ecological economist specializing in measuring the sustainable well-being of communities. Most recently he has become a best-selling book author with his first book *The Economics of Happiness: Building Genuine Wealth*, published in May of 2007, provides a new road map for countries, communities and companies to build a new economy of well-being using Mark's Genuine Wealth assessment model for measuring and managing economic, social and ecological well-being.

Mark wears many hats as an ecological economist, entrepreneur, professor, author and president of his family-owned consulting firm, Anielski Management Inc. He has dedicated the past 25 years of his life to developing new tools for measuring the sustainability and genuine well-being of nations, communities, businesses and organizations. He has served as an economic advisor to several countries and communities including: China, Innsbruck (Austria), the City of Edmonton, the City of Santa Monica, the City of Leduc and the Government of Alberta.

For 14 years he served as senior economic policy advisor and expert in performance measurement with the Alberta Government. He pioneered natural capital accounting in Alberta in the early 1990s and worked on the US Genuine Progress Indicator (GPI) in 2000. In 2001, he led a team of researchers at the Pembina Institute to complete the Alberta GPI Sustainable Well-being assessment, a longitudinal study of Alberta's economic, social and ecological sustainability. Between 2004-2007 he served as a senior foreign economic advisor to help China develop a *green* GDP accounting system and a system for measuring well-being for China's national economic policy of *xiaokang* (a Confucian term describing a society of modest means).

In 2008 and again in 2009 he completed the first municipal GPI assessment for the City of Edmonton using 50 economic, social and environmental indicators to evaluate sustainable well-being, including the Ecological Footprint analysis. He has conducted Ecological Footprint analysis, with his associated Jeff Wilson, for all major Canadian cities (Federation of Canadian Municipalities, 2004), for the City of Calgary, the town of Oakville, the province of Alberta (major cities and towns), and for the province of Ontario.

Mark also serves as an adjunct professor at the University of Alberta, School of Business teaching corporate social responsibility and social entrepreneurship.

Mark is the past-President of the Canadian Society for Ecological Economics, a Senior Advisor to the International Institute for Sustainable Development, Treasurer of the Strathcona Community League, and member of the board of Live Local. Mark lives in Edmonton with his wife and their two daughters.

Abstract

The Ecological Footprint (EF) measures the amount of biologically productive land and sea area an individual, a region, all of humanity, or a human activity requires to supply the resources used for food, energy, shelter, transportation, goods and services and absorb the waste emitted in providing goods and services.

The EF of a person is calculated by considering all of the biological materials consumed and all of the biological wastes generated by that person in a given year. All these materials and wastes are then individually translated into an equivalent number of global hectares.

In 2008, Edmonton's average EF was 8.56 global hectares per person (gha/capita; a total area for a total footprint area 6,440,612 hectares for an urban population of 752,412. If every one on earth lived like Edmontonians, we would need about 3.2 planets. Edmonton's footprint is estimated at, which is 92 times larger than the geographic area of the city (69,980 hectares). Between 1981 and 2008, Edmonton's EF grew by 43.6% or 1.97% per annum driven primarily by an increase in personal consumption expenditures.

The largest component of Edmonton's 2008 EF by land category is energy land or carbon footprint (56.8%), followed by crop land (17.8%), forest land (16.3%), built area (4.9%), pasture land (2.6%), and fishing ground (1.2% or 0.10 gha/capita). When broken down by consumption category, Edmonton's EF is dominated by shelter (30.9%) food (21.4%), government services (14.1%), services (13.9%), goods (10.5%), and transportation (9.1%). Energy or the carbon footprint is by far the key contributor to Edmonton's EF.

In 2004 Edmonton had the second highest EF amongst Canadian cities, after Calgary. This was due primarily to Alberta's relative large carbon footprint due to the use of coal-fired electricity and natural gas. Compared with the Canadian average EF, Edmonton's EF in 2004 was 30% larger.

In 2008, Edmonton's EF of 8.56 gha/capita was 3.2 times greater than the world's average of 2.7 gha/capita and 4.1 times greater than the planet Earth's biocapacity of 2.1 gha per person.

When compared with other countries Edmonton's EF had one of the largest per capita ecological footprints in the world, ranking fifth behind the United Arab Emirates, the United States, Kuwait and Denmark. Edmonton exceeded the average footprint of high-income countries by over 24%. Compared to benchmark Nordic countries, Edmonton compared favourably with Denmark (8.0 gha/capita) but is 15% larger than Norway (6.9 gha/capita) and

56% larger than Sweden (5.1 gha/capita). These Nordic countries serve as reasonable benchmarks for Alberta and Edmonton given similar climatic and socio-economic conditions.

Edmonton's relative large EF is partly due to a relatively large energy or carbon footprint (which makes up 56.8% of Edmonton's EF) and relatively healthy high consumptive and material lifestyle. Compared to other Canadian cities Edmonton's energy land (carbon) footprint was between 1.12 gha/capita or 23.6% larger than Ottawa and 1.81 gha/capita or 44.7% larger than Toronto. Compared to Nordic country benchmarks, Edmonton's carbon footprint 3.5 times larger than Finland 3.8 times larger than Norway and 6.1 times larger than Sweden. Moreover, Edmonton has a lower population density than most Canadian cities and most Nordic cities.

Like most North American cities, Edmonton's ecological footprint, in total area and per capita, far exceeds its geographic area and far exceeds its fair share of the global available biocapacity. This implies that the material lifestyles of more than three-quarters of a million Edmontonians is not sustainable if the goal were to live within the ecological capacity of the land base we occupy. In order to sustain our consumptive demands on nature requires significant imports of energy, food and other materials (the equivalent of 6.37 million hectares of land, an area almost the size of Sri Lanka which has 20 million people) into the Edmonton economy from outside our geographic area.

The good news is that Edmonton enjoys a healthy surplus of biocapacity in relationship to the provincial available biocapacity and Canada's available biocapacity; over 2 times greater than Edmonton's current per capita EF. However, should we feel comfortable enjoying a healthy biocapacity surplus or feel an ethical and ecological sense responsibility to other world citizens to reduce our footprint to a one-planet lifestyle?

There are many simple ways Edmontonians could reduce their ecological footprint including[1]:

- Use cleaner transportation.
- Add energy saving features to your home.
- Adopt energy-saving habits.
- Reducing your food footprint by eating more locally and in-season foods.
- Choose sustainable building materials, furnishings and cleaning products.
- Adopt water saving habits
- Reduce your goods and services footprint by buying less, recycling and composting.

In general, a less materially consumptive lifestyle would result in a decrease in Edmonton's EF. However, convincing people to consume and adopt a simpler lifestyle voluntarily will be difficult, at best.

Encouraging marginal shifts in behaviour should result in measurable reductions in both energy and material consumption.

[1] See http://www.myfootprint.org/en/take_action/reduce_your_footprint/ for a list of footprint reduction lifestyle opportunities.

The good news is that it would appear that Edmonton's total GHG emissions per capita have been declining since their peak in 2000 along with decreasing per capita natural gas and electricity consumption. While it is not clear what factors are behind this positive trend (e.g. improved household energy efficiencies), the result is that Edmonton's overall EF should begin to show a decline given the significance of the carbon footprint component.

Discussion Paper

What is the Ecological Footprint?

The Ecological Footprint (EF) measures the amount of biologically productive land and sea area an individual, a region, all of humanity, or a human activity requires to supply the resources used for food, energy, shelter, transportation, goods and services and absorb the waste emitted in providing goods and services. [2] This demand on nature is then compared with how much land and sea area is available to a human population within a geographic region.

The EF answers the question: How much of the biological capacity[3] of the planet is required by a given human activity or population? It also answers the key sustainability question for Edmonton: how many planets were necessary to support all of the people that lived in the City of Edmonton in a given year, under that year's standard of living, biological production and technology?

EF analysis provides a useful tool for assessing whether a community is living in harmony with nature's capital goods and services or is incurring an ecological deficit.

EF analysis may be used by decision makers to assess whether a community is on a sustainable path. It can also be used to compare lifestyles globally and identify inequalities of resource use.

The EF can also educate people about sustainable living, with the aim of altering personal behavior.

How is the Ecological Footprint calculated?

The EF of a person is calculated by considering all of the biological materials consumed and all of the biological wastes generated by that person in a given year. All these materials and wastes are then individually translated into an equivalent number of global hectares.

To accomplish this, the amount of material consumed by that person (tonnes per year) is divided by the yield of the specific land or sea area (annual tonnes per hectare) from which it

[2] Global Footprint Network http://www.footprintnetwork.org/en/index.php/GFN/page/frequently_asked_questions/#method1 accessed May 10, 2010.

[3] Biocapacity is shorthand for biological capacity, which is the ability of an ecosystem to produce useful biological materials and to absorb wastes generated by humans.

was harvested, or where its waste material was absorbed. The number of hectares that result from this calculation are then converted to global hectares using yield and equivalence factors. The sum of the global hectares needed to support the resource consumption and waste generation of the person is that person's EF.

The EF of a group of people, such as a city or a nation, is simply the sum of the Ecological Footprint of all the residents of that city or nation.[4]

The EF of an activity, such as producing a good (an airplane) or service (providing insurance) in the human economy, is calculated by summing the Ecological Footprint of all of the material consumed and waste generated during that activity. When calculating the Footprint of a business or an organization, the activities to be included within the boundaries of that organization must be clearly defined. [5]

A common global methodological standard for calculating EF estimates has been established by the Global Footprint Network (GFN) (www.footprintnetwork.org). The calculation of Edmonton's EF and other Canadian cities[6] follows the GNF methodological standards and entailed two calculations:
a) the demand for land and sea area to meet current material and energy demands by Canadian households, then adjusted for Edmonton using various adjustment variables including relative differences in household expenditures, energy consumption statistics, GHG emissions, household size and travel distances and mode of transportation, and;
b) the biologically productive land and sea available, both locally and anywhere on the planet, to provide for these household material and energy demands.[7]

The EF is measured in global hectares (gha); a global hectare is a common unit that encompasses the average productivity of all the biologically productive land and sea area in the world in a given year. Biologically productive areas include cropland, forest and fishing grounds, and do not include deserts, glaciers and the open ocean. Using a common unit, i.e., global hectares, allows for different types of land to be compared using a common denominator. Equivalence factors are used to convert physical hectares of different types of land, such as cropland and pasture, into the common unit of global hectares.

[4] It is also possible to construct an Ecological Footprint of production for a city or nation, which instead sums the Ecological Footprint of all resources extracted and wastes generated within the borders of the city or nation.
[5] Global Footprint Network http://www.footprintnetwork.org/en/index.php/GFN/page/frequently_asked_questions/#method1 accessed May 10, 2010.
[6] The EF was calculated for Edmonton by Anielski (2009) in The Edmonton 2008 Genuine Progress Indicator Report, for Alberta (Anielski and Wilson, 2008) and for Canadian cities (Wilson and Anielski, 2004) using standard EF accounting methods developed by the Global Footprint Network (GFN).
[7] There are different methods for calculating the EF used by various ecological footprint studies. Examples include how sea area should be counted, how to account for energy land that absorbs carbon from energy consumption, how to account for nuclear power, which data sources should be used, and how ecological capacity should be calculated. However, common methodological standards are emerging through the work of the Global Footprint Network.

Calculation of Edmonton's EF

Calculation of Canadian municipal footprints, including the City of Edmonton, involved both a demand-side and a supply-side calculation. On the demand side, the EF[8] uses national (Canadian) average production and yields of primary products (from cropland, pasture land, forest, and fisheries) to calculate the area of land and sea necessary to support a given household consumption category (food, shelter, transportation, goods, other services, and government services) plus the estimated biologically productive land area required to absorb carbon emissions (energy land) from energy consumption emissions for households.

The calculation of the cropland and pastureland footprint is only possible at the national level. Provincial and municipal estimates use the national-level food production yields statistics and then adjust these using provincial and municipal household consumption expenditure data for food.[9] The sub-national footprint calculation strategy adjusts national EF estimates based on proxies for the major consumption categories of the EF: food, shelter, transportation (mobility), goods, services, and government.

The calculation of energy lands (or 'carbon footprint') is based on energy consumed (by type of fuel source) and the tonnes of carbon (GHG) emitted, both from direct sources (i.e. fossil fuel combustion) and from indirect emissions (for products manufactured abroad). It measures the amount of biological capacity, in global hectares, demanded by human emissions of fossil carbon dioxide. Carbon emissions vary by type of fuel combusted for energy (e.g. electricity (hydro or coal-fired plants), natural gas, heating oil, propane, and wood). Fuel consumption for space heating (GJ of natural gas) and electricity production (kwh) statistics are available for Alberta; a shorter time series is also available for the City of Edmonton, which was used in the Edmonton EF estimates for the period 1997-2008. GHG emissions statistics are from Environment Canada GHG inventory statistics for Alberta. These GHG emissions statistics are subsequently used to estimate the area of land (forests, wetlands, agricultural soils) that could absorb or sequester these carbon emissions. Because different energy sources have different carbon intensities, the energy land (carbon footprint) estimates can vary greatly across Canada (e.g. B.C., Ontario and Quebec have much lower energy land footprints because of their use of hydro-electricity while Alberta or Saskatchewan have higher footprints due to coal-fired electrical facilities). In addition, data on residential greenhouse gas (GHG) emissions related to natural gas and electricity consumption from the City of Edmonton was used to calibrate the energy lands footprint component.

On the supply side, the biocapacity required to meet the household material and energy consumption demands is measured by calculating the amount of biologically productive land and sea area available to provide the resources a population consumes and to absorb its wastes, given current technology and management practices. Countries and regions differ in

[8] The Ecological Footprint was originally developed at the University of British Columbia in 1996 by Dr. Bill Rees and Mathis Wackernagel.

[9] The sub national Ecological Footprint calculation approach adapts the Canadian Consumption Land Use Matrix (CLUM) developed by the Global Footprint Network (2008) using the consumption expenditure model developed to assess the Ecological Footprint of Federation of Canadian Municipalities (FCM) communities by Wilson and Anielski (2004) and refined by Wilson and Anielski (2008).

the productivity of their ecosystems as reflected by the nature and area of various land cover types (e.g. forest, agricultural land).

The accuracy and dependability of EF analysis ultimately depends on the veracity of the underlying data sets. EF analysis at the municipal level for Edmonton draws from numerous national data sources including Alberta government statistics, Statistics Canada (e.g. Census data), the Food and Agricultural Organization (FAO), and other data sources (e.g. GFN). There are some shortcomings to robust EF analysis including:

- Lack of food consumption statistics (in terms of volume) that are specific to Alberta and Edmonton.
- Cannot distinguish between locally-sourced food, materials and energy and imported.
- Lack of longitudinal or historical GHG emissions and energy use data for the City of Edmonton.
- Lack of estimates of the carbon sequestration capacity of Alberta landscapes.

How large is Edmonton's Ecological Footprint?

The City of Edmonton's Ecological Footprint in 2008 was estimated at 8.56 global hectares (gha) per capita.[10] With an estimated population of 752,412 people the total area of Edmonton's footprint is estimated at 6,440,612 hectares in size, which is 92 times larger than the geographic area of the city (69,980 hectares).

The largest component of Edmonton's 2008 EF by land category is energy land or carbon footprint (56.8% or 4.86 gha/capita), followed by crop land (17.8% or 1.52 gha/capita), forest land (16.3% or 1.39 gha/capita), built area (4.9% or 0.42 gha/capita), pasture land (2.6% or 0.22 gha/capita), fishing ground (1.2% or 0.10 gha/capita) and total hydro reservoir (0.4%) (See Table 1.).

Table 1: Edmonton EF by Land Category and Consumption Category, 2008

EF Edmonton by Land Category			EF Edmonton by Consumption Category		
	gha/capita	% of total		gha/capita	% of total
Pasture land	0.22	2.6%	Food	1.83	21.4%
Crop land	1.52	17.8%	Shelter	2.65	30.9%
Forest land	1.39	16.3%	Transportation	0.78	9.1%
Fishing ground	0.10	1.2%	Goods	0.90	10.5%
Built area (non-hydro)	0.42	4.9%	Services	1.19	13.9%
Total hydro reservoir	0.04	0.4%	Government	1.21	14.1%
Energy land/carbon footprint	4.86	56.8%			
Total	8.56	100.0%	Total	8.56	100%

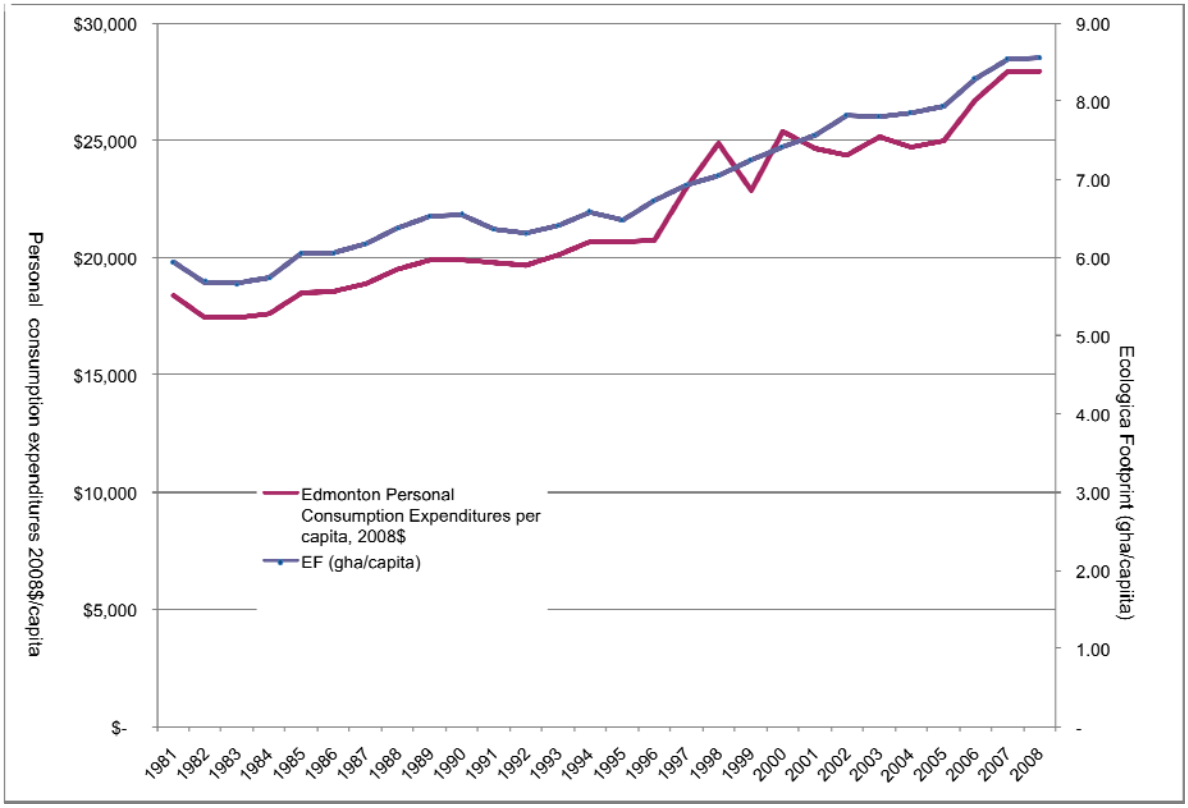
Source: Anielski Management Inc.

When broken down by consumption category (see Table 1), Edmonton's EF is dominated by shelter (30.9%) food (21.4%), government services (14.1%), services (13.9%), goods (10.5%), and transportation (9.1%). Energy is a key component of all of these consumption categories.

Edmonton's EF has been growing steadily; between 1981 and 2008 the EF grew by 43.6% or 1.97% per annum driven primarily by an increase in average personal consumption expenditures (in constant 2008 dollars) per capita, which has increased by 51.6% between 1981 and 2008 (see Figure 1).[11] By comparison, Edmonton's real GDP per capita (in constant $2008), a measure of total economic growth, increased by 22.1% between 1981 and 2008.

[10] This estimates differs from the 10.1 gha/capita estimated and reported in the Edmonton 2008 Genuine Progress Indicator report and cannot be compared The changes are due to new information on GHG emissions and energy consumption data.
[11] Based on analysis contained in The Edmonton 2008 Genuine Progress Indicator Report by Anielski Management Inc. (2009).

Figure 1: Trends in Edmonton's EF Compared with Edmonton Personal Consumption Expenditures per capita ($2008), 1981-2008



Source: Anielski Management Inc. Personal consumption expenditure data is from Statistics Canada Table 203-0001 - Survey of household spending (SHS), household spending, and summary-level categories, by province, territory and selected metropolitan areas

Is Edmonton's food footprint sustainable?

Edmontonians consumed 1.74 gha/capita of cropland and pastureland (as a source of food) somewhere in the world in 2008. We might call this area of land 'food land.' The total food land required to meet Edmonton's food consumption lifestyle (for 752,000 or more people) would total 1,309,737 hectares of land. However, the City of Edmonton only has 27,860 hectares of agriculture-zoned land (almost 40% of the City of Edmonton's total area) within its boundary capable of; it is not known how much of this area is dedicated to local food production. Even if all of this land were dedicated to local food production, Edmonton's agricultural lands could only meet 2.1% of Edmontonian's current food demands. Thus, Edmonton's current food footprint is not locally sustainable without significant volumes of food imports.

How much biocapacity is available to meet Edmonton's ecological footprint?

Edmonton's total EF in global hectares is 6,440,612 hectares or roughly 92 times greater than the total land area of the City of Edmonton (69,980 hectares). Of the total land area of

about 48% (33,850 hectares) is agricultural zoned land and other green space (i.e. 'biocapacity') while 52% (36,130 hectares) is built-up area (residential, industrial, commercial, institutional and other developed). This means that there are only 0.045 gha of local biocapacity available per Edmontonian to meet the current 8.56 gha/capita demands of Edmontonians. This implies that without imports of food, energy and materials from somewhere else on the planet, Edmonton would not be self-sufficient or sustainable.

So what? Most cities in the world are similar to Edmonton relying heavily on imports to sustain their current quality of life.

How much biocapacity is available from Alberta and Canada to service Edmonton's EF demand? The estimated available biocapacity in 2008 for the province of Alberta was 63,867,740 hectares or 18.38 gha per Albertan. This would suggest that Alberta's available biocapacity could easily meet the current EF demand of Edmontonians Edmonton's current total EF (6,440,612 hectares; Edmonton would demand only 10.1% of the available provincial biocapacity. Even more favourable is the fact that Canada's current estimate available biocapacity is over 20 gha/capita.

Table 2: Available Land (biocapacity) in Alberta and Edmonton (hectares per capita), 2008

Available land (ha/capita)	Alberta	Edmonton
Agriculture (Crop land/pasture)	5.99	0.04
Forest Land	11.63	0.01
Built-Up Land	0.13	0.05
Other Uses (sea/hydro)	0.63	
Total Land Area	**18.38**	**0.09**

However, what is not known is how much of this available Alberta or Canadian biocapacity is actually used to provide for Edmontonian's food, shelter, and energy needs.

While Edmontonians and Albertans might feel comfortable with their natural capital advantage, from a global context, Edmonton's EF and share of the planet's biocapacity is inequitable. In 2008, Edmonton's EF of 8.56 gha/capita was 4.1 times greater than the planet Earth's 2.1 gha of biocapacity per person (2005) currently available on the planet and 3.2 times greater than the world's average EF of 2.7 gha/capita (2005).[12] The world's population, as a whole, is already in a significant ecological deficit with an EF 'overshoot' of 28.5% above the earth's biocapacity.

How does Edmonton's carbon footprint compare with the carbon sequestration capacity of the watershed in which Edmonton is situated? According to City of Edmonton GHG emission statistics for 2008, total emissions in 2008 were an estimated 18.441 million tonnes of CO_2e (6.2 million tonnes or 33.6% were from residential sources). By comparison, a recent study of the net carbon sequestration capacity (i.e. net biome productivity) of Edmonton's North Saskatchewan watershed estimates that only 0.207 million tonnes of CO_2e were absorbed on

[12] According to the Global Footprint Network and the Living Planet Report 2008, the average global biocapacity has steadily declined from 4.2 gha/person in 1961 to 2.1 gha/person in 2005.

average per annum between 2000 to 2003, implying that Edmonton is running a significant carbon deficit with nature in excess of 18.2 million tonnes of CO_2e.[13]

How does Edmonton's Ecological Footprint compare with others?

Edmonton's EF is larger than the majority of Canadian cities and other country benchmarks, such as Norway, Sweden and Finland. In a 2004 study (Wilson and Anielski, 2004) of Canadian municipal EFs, Edmonton's EF (9.45 gha/capita) [14] was ranked second overall after Calgary, with Ottawa, Halifax, Vancouver and Toronto ranked after the two Alberta cities (see Table 3). Compared with the Canadian average EF, Edmonton's EF in 2004 was 30% larger. This earlier Edmonton EF estimate 9.45 gha/capita cannot be compared with the current 2008 EF estimate for Edmonton.

Table 3: Comparison of Edmonton's EF to Other Canadian Cities, 2004

City	EF (gha/capita)
Calgary	9.86
Edmonton	**9.45**
Ottawa	8.59
Halifax	7.83
Vancouver	7.71
Toronto	7.36
Canadian average	7.25

Source: Wilson, J., and M. Anielski. 2004. Ecological Footprint of 18 Canadian Municipalities. Ottawa. Prepared for the Federation of Canadian Municipalities.

By global comparisons Edmonton's estimated EF in 2005 of 7.9 gha/capita[15] was 2.9 times larger than the global average Ecological Footprint of 2.7 gha/capita, based on the most recent 2008 Global Footprint Network report (reporting for the year 2005).

When compared with other countries Edmonton's EF had one of the largest per capita ecological footprints in the world (see Table 4), ranking fifth behind the United Arab Emirates, the United States, Kuwait and Denmark. Edmonton exceeded the average footprint of high-income countries by over 24%. Compared to benchmark Nordic countries, Edmonton compared favourably with Denmark (8.0 gha/capita) but is 15% larger than Norway (6.9 gha/capita) and 56% larger than Sweden (5.1 gha/capita).

[13] Carbon sequestration statistics are based on net biome productivity (NBP) estimates – the annual net absorption (or release) of carbon by Canada's forests and wetlands –by Prof. Jeng Chen, a geographer at the University of Toronto who has conducted longitudinal research the carbon cycle of Canada's forests between 1900-2003. Net Biome Productivity can be defined as a measure of the net carbon sequestration or release capacity of forests , wetland or other land cover and is measured as the difference between Net Primary Productivity (carbon absorbed by plants) less Autotrophic Respiration (releases by plants) and Hetertrophic Respiration (carbon released from soils) , less the carbon effects of fire, timber harvesting, and insect-induced mortality.

[14] These earlier estimates of Edmonton's EF for 2004 do not match more recent EF estimates for Edmonton due to improved data on energy consumption, GHG emissions and other household expenditure data. For example our revised 2004 estimate for Edmonton's EF/capita is 7.86 gha/capita (see Appendix 1) versus 9.45 gha/ha as per the FCM study of 2004.

[15] Since only 2005 EF estimates are available for other countries in the 2008 Living Planet Report we used Edmonton's EF estimate for 2005 to compare with other nations. See Appendix 1 for a raw data time series for Edmonton's EF.

These Nordic countries serve as reasonable benchmarks for Alberta and Edmonton given similar climatic and socio-economic conditions.

Table 4: Countries with the Largest Ecological Footprints, 2005

Largest Ecological Footprints	EF/ Capita
United Arab Emirates	9.5
United States of America	9.4
Kuwait	8.9
Denmark	8.0
Edmonton *	**7.94**
Australia	7.8
New Zealand	7.7
Canada	**7.6**
Norway	6.9
Estonia	6.4
Finland	5.2
Sweden	5.1
Switzerland	5.0
Germany	4.2
World	**2.7**
High income countries	6.4
Middle income countries	2.2
Low income countries	1.0

Source: Global Footprint Network, Living Planet Report 2008.
* Figures are for the year 2005; Edmonton's EF figure is for the year 2005 and thus differs from the 8.56 gha/capita for the year 2008.

What accounts for Edmonton's larger footprint?

Edmonton's relative large EF is partly due to relatively healthy high consumptive and material lifestyle as reflected in high and increasing real levels personal consumption expenditures. Over the last 10 years (1998-2008), real consumption expenditures per capita increased 1.28% per annum while the average EF per Edmontonian increased 1.97% per capita.[16] In general, the more we spend on housing/shelter (31.3% of current consumption expenses[17]), transportation (21.0% of expenses), other goods (e.g. clothing, household furnishing, personal care products, etc. at 14.6% of expenses) and services (e.g. health care, recreation, etc.) at 13.3% of expenses), which tend to be energy intensive, the greater of footprint.

Edmonton also has a relatively large energy or carbon footprint, which makes up the majority (56.8%) of Edmonton's EF. Compared to other Canadian cities Edmonton's energy land (carbon) footprint was between 1.12 gha/capita or 23.6% larger than Ottawa and 1.81 gha/capita or 44.7% larger than Toronto (see Table 5). Compared to our Nordic country benchmarks, Edmonton's energy lands (carbon) footprint is significantly higher particularly compared with Finland (3.48 X more), Norway 3.77 X more), and Sweden (6.15 X more).[18]

[16] The EF per capita was rising faster than personal consumption expenditures because energy consumption was rising faster than other expenditure categories.
[17] Based on the breakdown of estimated current consumption expenditures by household expenditure categories for the City of Edmonton for 2008
[18] The extremely low carbon footprint for Sweden cannot be explained without an inquiry with Global Footprint Network. This estimates appears unusually low compared with other countries such as the UK (3.51 gha/capita), Germany (2.31 gha/capita), France (2.52 gha/capita), and neighbouring Finland (1.68 gha/capita)

Moreover, Edmonton has a lower population density than most Canadian cities and most Nordic cities.

Table 5: Energy Land (Carbon) Footprint Comparisons

City or Country	Energy land (carbon footprint), gha/capita	Indexed relative to Edmonton	Total EF (gha/capita)	Median annual temperatures (degrees C), 1981-2000 [3]	Population City Densities (persons/km^2) [4]
Edmonton (2004)[19]	5.85	100.0	9.4	2.37	1,099
Calgary (2004)	6.03	103.7	9.9	4.05	1,435
Vancouver (2004)	4.21	71.9	7.7	10.07	5,335
Ottawa (2004)	4.74	80.9	8.6	6.00	292
Toronto (2004)	4.05	69.1	9.2	9.13	2,972
Halifax (2004)	4.52	77.3	7.8	6.26	n.a.
Nordic Country Benchmarks					
Denmark (2005)	3.53	73.6	8.0	8.04 (Copenhagen)	5.985 (Copenhagen)
Finland (2005)	1.68	35.0	5.2	4.80 (Helsinki)	2,735 (Helsinki)
Norway (2005)	1.55	32.3	6.9	5.98 (Oslo)	1,292 (Oslo)
Sweden (2005)	0.95	19.8	5.1	6.79 (Stockholm)	4,112 (Stockholm)
World average (2005)			2.7		

Sources: 1. Canadian cities source is Wilson, J., and M. Anielski. 2004. Ecological Footprint of 18 Canadian Municipalities. Ottawa. Prepared for the Federation of Canadian Municipalities. 2. Global benchmarks source is Global Footprint Network, Living Planet Report 2008. 3. Median of monthly mean daily minimum and daily maximum temperatures averaged over a calendar year for years 1981-2000 for Canadian cities and 1961-1990 for European cities as reported by the World Meteorological Organization http://www.worldweather.org accessed May 2008. 4. City population density statistics were sourced from Wikipedia.org for respective cities.

Can Edmonton and Canada's cold climate account for our larger energy (carbon) footprint per capita? Comparing average annual temperatures (Table 5) suggests that Edmonton has been, on average, two to three colder than Helsinki, Finland (ave. annual temperature of 4.8 ºC) or Copenhagen, Denmark (ave. annual temp. 8.0 ºC). This would certainly account for higher home space heating energy consumption and costs. Energy consumption affiliated with the average Alberta home accounts for a quarter of the total Alberta's ecological footprint (Anielski Management Inc, 2008). Approximately 60% of that amount can be attributed to space heating using primarily natural gas. In addition, Alberta's electricity is primarily from coal-fired plants, which have higher GHG emissions per kwh and thus a higher carbon footprint than Ontario, Quebec and B.C, with hydropower. With the largest component of Edmonton's EF being dedicated to housing or shelter (30.9% in 2008, see Table 1), it may reasonable to expect our energy consumption to be greater than other Canadian cities and Nordic country benchmarks.

Another factor driving Edmonton's footprint is food consumption, contributing 21.4% to the average Edmonton EF in 2008. The majority of our food is imported from somewhere outside of the Edmonton geographic area and may travel an average of over 2,400 kilometers from the land of production to Edmonton households, thus has a high-imbedded carbon footprint.[20]

[19] Note: Edmonton's carbon footprint has since declined about 1.0 hectare since 2004 to an estimated 4.86 gha/capita

[20] Exact statistics on how much of Edmonton's food consumed is imported are not available. Michael Pollen, author of the *Omnivore's Dilemma*, estimates that in North America the average food item travels over 1,500

Another important factor driving Edmonton's rising EF is transportation contributing 9.1% to Edmonton's EF in 2008. Moreover, transportation expenditures made up 21.0% of the average Edmonton households current consumption expenditures in 2008, second only to expenditures on shelter. Between 2001 and 2008 the real average household expenditures on private and public transportation per capita[21] increased by 25.0%, the litres of gas and diesel consumed by residential vehicles per capita increased by 31.2% (between 2003-2008) or 5.6% increase per annum to reach 2,664 litres per capita in 2008.[22] Average commuting distances increased from 7.6 km/commute in 2001 to 7.8 km/commute in 2006.[23] According to Statistics Canada (2006), 69.7% of Edmonton workers travel to work in their personal vehicle as the driver, 9.5% travel by carpool, 11.5% use public transportation, and 8.0 % either walk or cycle.[24]

Some might believe Edmonton's EF is so large due to its industry and economic base, particularly the petrochemical industry, however, the EF only considers the ecological demands of households in Edmonton and not the impacts of industry. In fact, of Edmonton's total 18.4 million tonnes of GHG emissions (CO^2e) in 2008, only 33.6% came from residential consumption of natural gas, electricity and private transportation, while the majority 76.3% of GHG emissions comes from industrial and commercial sources. Of course, some of the production of goods and services by commercial and industrial agents operating in Edmonton is being consumed locally, which would be part of the Edmonton EF. However, a considerable amount of this production is being exported to other markets and thus consumed by other households in these export regions. This suggests that the Edmonton EF as calculated would underestimate the total demands on biocapacity (local, provincial and national), particularly the carbon footprint. Such a full impact accounting would require a comprehensive natural capital account and energy-material flow account for Edmonton and Alberta.

What are the long-term implications for Edmonton of having such a large Footprint?

Like most North American cities, Edmonton's ecological footprint, in total area and per capita, far exceeds it's geographic area and far exceeds its fair share of the global available biocapacity; Edmonton's ecological overshoot is 92 times greater than the available biocapacity or land base of the City of Edmonton. This implies that the material lifestyles of

miles or 2,400 kilometers from farm field to table. Eating local food and growing your own food offers an opportunity to lower the ecological footprint of food consumption. Based on our EF analysis, we estimate that at least 98% of Edmontonian's food land (crop and pasture land) is sourced outside of the Edmonton geographic area.

[21] Based on personal consumption expenditure statistics from Statistics Canada. Table 203-0001 - Survey of household spending (SHS), household spending for Edmonton CMA converted to City of Edmonton proper estimates.

[22] Based on City of Edmonton, Environment Branch statistics provided for the Edmonton 2009 GPI report.

[23] Edmonton's commuting distance of workers was slightly higher than the Canadian median commuting distance of 7.5 km/commute but lower than Calgary (8.20 km), Ottawa (8.10 km) and Toronto (9.40 km).

[24] 1.3% of commuters used another mode of transportation.

more than three-quarters of a million Edmontonians is not sustainable if the goal were to live within the ecological capacity of the land base we occupy. In order to sustain our consumptive demands on nature requires significant imports of energy, food and other materials (the equivalent of 6.37 million hectares of land, an area almost the size of Sri Lanka which has 20 million people) into the Edmonton economy from outside our geographic area.

While Edmonton may not be in harmony ecologically with its own geographic biocapacity, the good news is that Edmonton enjoys a healthy surplus of biocapacity in relationship to the provincial available biocapacity and Canada's available biocapacity; over 2 times greater than Edmonton's current per capita EF. However, should we feel comfortable enjoying a healthy biocapacity surplus or feel a sense responsibility to reduce our footprint for the benefit of the average world citizen who lives on a footprint less than one-third our size?

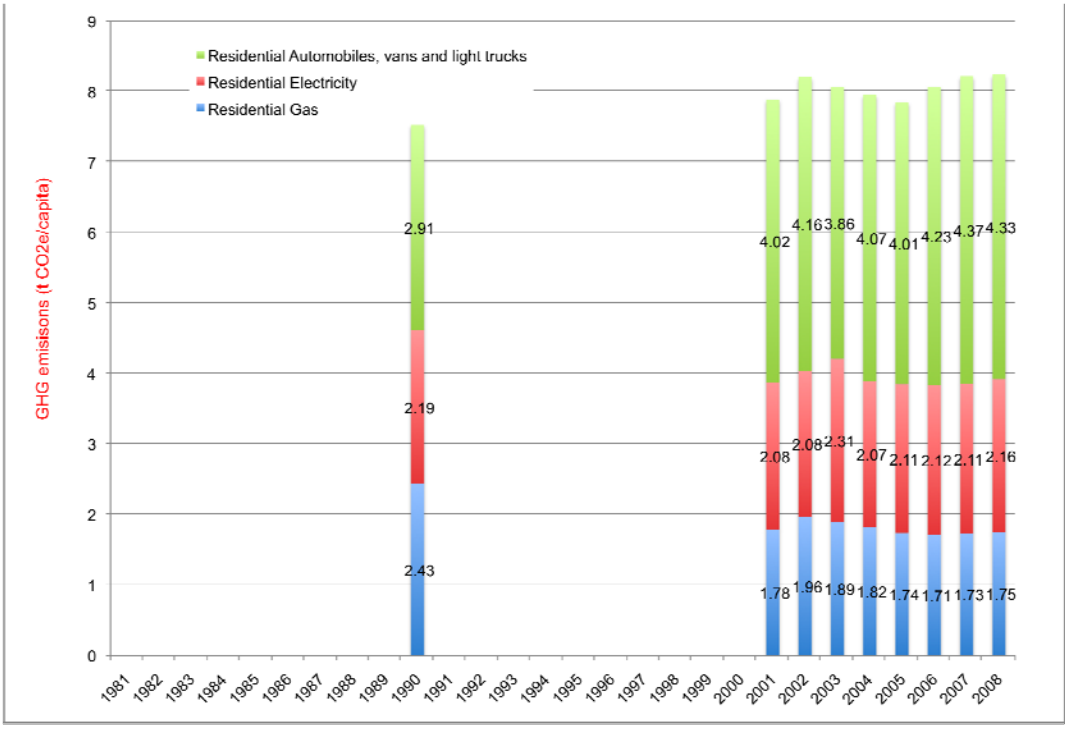
If the last 10-year trends continue — an average annual 1.8% increase in Edmonton's population, a 2.0% annual increase in Edmonton's per capita EF, a 1.3% annual increase in personal consumption expenditure per capita, and an annual 0.6% increase in GHG residential emissions per capita[25] — then Edmonton's total EF area and per capita EF will continue to increase. The good news is that per capita GHG residential emissions appear to have stabilized between 2001 and 2008 (see Figure 2). This is also true of total Edmonton GHG emissions (all sources), which have remained between 18.1 million and 18.7 million tonnes of CO2e between 2001 and 2008.

Moreover, Edmonton's carbon footprint far exceeds the capacity of the North Saskatchewan watershed to absorb the increasing amount of total GHG emissions as Edmonton's population increases. This is unlikely to change as climate change impacts are expected to exacerbate carbon fluxes.

The good news is that the growth in real consumption expenditures per capita is rather moderate, at 1.9% per capita per annum between 1997-2008, with relatively modest per annum increases in food expenditures (+ 0.3% per annum), shelter and clothing (+1.5% per annum), household operations (+1.7% per annum). The largest increase has been in private and public transportation expenditures (+3.0% per year). If average vehicle fuel consumption per capita continues to increase at 5.6% per annum (the past 5-year rate) and commuting times continue to increase we can expect the transportation portion of Edmonton's EF will continue to rise.

[25] This is the annual average increase in GHG emissions for residential gas, electricity and vehicles per capita between 2001-2008.

Figure 2: Residential Greenhouse Gas Emissions (tonnes of CO2e) per capita, Gas, Electricity and Private Vehicles, Edmonton 1990, 2001-2008



What level of reduction in Edmonton's Footprint is possible?

What opportunities are there for reducing Edmontonian's EF through changes in our materialist life style? What can be learned from more energy efficient and compact benchmark communities in Canada or in Nordic countries, with similar socio-economic and climate conditions? Could Edmonton households reduce their EF from 8.56 gha/capita to the Norwegian average of 6.92 gha/capita, a 1.6 gha/capita or 19 % reduction? Or better yet, match the average Swedish EF of 5.10 or a 3.5 gha/capita or 40% reduction?

Are there economically feasible energy savings technologies, urban community design options, and changes in lifestyles (e.g. commuting, eating locally) that might reduced Edmontonian's energy (carbon) footprint of 4.68 ha/capita to come closer to the average Norwegian energy footprint of 1.55 gha/capita or the average Finnish energy footprint of 1.68 gha/capita?

The answers depend on a full cost accounting of various technological and behavioural 'wedges' or options that Edmonton might explore to encourage households and businesses to reduce the carbon footprints and overall EF. Such opportunities would require detailed analysis of the energy footprint savings from adoption of the various energy efficiency and renewable energy options available to Edmonton.

There are many simple ways Edmontonians could reduce their ecological footprint including[26]:

- Use cleaner transportation.
- Add energy saving features to your home.
- Adopt energy-saving habits.
- Reducing your food footprint by eating more locally and in-season foods.
- Choose sustainable building materials, furnishings and cleaning products.
- Adopt water saving habits
- Reduce your goods and services footprint by buying less, recycling and composting.

In general, a less materially consumptive lifestyle would result in a decrease in Edmonton's EF. However, convincing people to consume and adopt a simpler lifestyle voluntarily will be difficult, at best. There are many examples of how people can live with less material throughput in their lives and yet optimize levels of well-being and happiness. These include changes in lifestyle such as eating more locally produced foods, taking public transit or biking or walking to work, or improving the energy efficiency of your home. These life choices if adopted by more Edmontonians, could reduce the total area of Edmonton's EF considerably.

Energy Conservation and Renewable Energy Substitution

Because of the City of Edmonton's relatively large energy or carbon footprint and relatively low population density, one the most opportune areas for the largest EF reduction would be through household energy savings, through efficiency retrofits, and substitution of carbon-intensive coal-fired electricity for less carbon-intensive renewable energy technologies. As new technologies come on line that affect biocapacity and resource-efficiency, their impact on resource supply and demand will be reflected in biocapacity and Footprint assessments.

Another opportunity is to encourage even greater population densification in Edmonton's urban core and discourage sprawl. In general, communities with higher population densities, more walkable communities and smart-growth characteristics will tend to have smaller carbon footprints and EFs.

An important accounting tool to track the impacts of new technologies and changes in lifestyle, would be to establish an energy and carbon accounting system for Edmonton. This account would be for households, businesses and governments, by neighborhoods, and according to the vintage of Edmonton's housing stock. Trends in total and per capita energy consumption and GHG emissions would be tracked against a baseline. In addition, a more forensic account of how much renewable energy capacity is being installed in Edmonton would be necessary. Furthermore, analysis of the impact of net energy saving technologies through home retrofits as well as energy audits of new construction, including recent net-zero energy housing[27] experiments, would assist in better determining what genuine carbon

[26] See http://www.myfootprint.org/en/take_action/reduce_your_footprint/ for a list of footprint reduction lifestyle opportunities.

[27] A net-zero energy home is capable of producing, at minimum, an annual output of renewable energy that is equal to the total amount of its annual consumed/purchased energy from energy utilities.

footprint reductions are available. What opportunities or incentives to home owners and housing developers could be put in place to encourage more net-zero energy home construction.

In the short to medium term, Edmonton, as a whole, may be constrained to substitute coal-fired electricity for renewable energy options though experience from the construction of net-zero energy home development suggest viable opportunities may exist to improve overall energy efficiency and reduce Edmonton's residential carbon footprint of Edmonton's housing stock.

Changes in Mode of Transportation

The most likely area of According to Statistics Canada census only marginally fewer people were taking public transit to work in 2006 (11.5%) than in 2001 (10.1%) and fewer people were walking and cycling to work (8.0% in 2006 and 8.4% in 2001). Taking public transit, walking, or cycling to work as opposed to commuting by car reduces the average person's footprint by approximately 0.50 hectares.[28] Traveling by car can generate up to thirteen times more CO_2e emissions than commuting by bus (assuming an average total commute of 20 km). Encouraging changes in the mode of transportation would help to reduce Edmonton's transportation component of the EF. With the recent expansion of Edmonton's Light Rail Transit (LRT) and future expansion plans, this should ultimately lead to a reduced energy footprint. While these are important behavioural wedges they generally amount to a relatively small reductions in the total EF of city.[29]

Increasing Local Food Production

With food consumption making up more than 21% of Edmonton's EF by consumption category, opportunities to produce food and consume it more locally thereby substituting more carbon-intensive food imports could significantly reduce Edmonton's food footprint. But can Edmontonians reduce their food consumption footprint that would be closer in harmony with the capacity of local agricultural lands to meet current needs?

With a per capita food footprint of roughly 1.8 gha/capita and only 0.04 gha/capita of agricultural land available within Edmonton, means that Edmonton is, at best, almost 98% dependent on imported 'food land.' Substituting some of these imported 'food lands' with higher-yield agricultural production on local agricultural lands might be an option, however, no thorough studies of such options have been conducted. Moreover, no reliable statistics exist

[28] Taking public transit as opposed to travelling by car would reduce the average Oakville footprint by 0.49 hectares. Walking or cycling as opposed to travelling by car reduces the average Oakville footprint by 0.51 hectares.

[29] For example, in a study by Wilson and Anielski (2010) for Oakville, Ontario (The Town of Oakville Ecological Footprint Analysis), their analysis showed that if 5% of current commuters who travel by single occupancy vehicle switched to public transit and another 5% opted to walk or cycle it would reduce Oakville's Ecological Footprint by only 1,580 hectares. If 25% of current commuters who travel by single occupancy vehicle switched to public transit and another 25% opted to walk or cycle it would reduce Oakville's Ecological Footprint by 7,885 hectares or reduce Oakville's EF of 9.0 gha/capita by 0.53%.

on the production and consumption of local food on either Edmonton urban agricultural lands nor on production on prime agricultural lands that border the City of Edmonton.

Are there agricultural lands available outside the City's boundary? In a 2006 study by Anielski Management Inc. for the city of Leduc and Leduc County, an estimated 97,326 hectares of prime agricultural land were identified within Leduc County (bordering Edmonton to the south) that could be suitable for growing market vegetables, livestock, poultry and other foods. However, how much of this land produced food sold in Edmonton local markets is unknown. In fact, a significant portion of production likely was exported to markets outside of Alberta. Even if all of this Leduc County land were available to Edmontonians it would only add 0.13 gha/capita to Edmonton's food land demand. If combined with the 0.04 gha/capita of urban agricultural land within Edmonton, Edmontonians could, at best, meet less than 10% of their current food land footprint from local land.

The bad news is that we have actually lost 12.1% (4,000 hectares) of agricultural land within our city boundary since 2003 and more losses may be likely with increasing housing and business development pressures.

Other options would include exploring changes in diet to more vegetable-rich diets; the average American vegetable consumption per year is less than 10%, by volume, of a total food consumption of 2,175 pounds per person per year. Changes in agricultural practices might lead to improved yields of produce. For example, SPIN (Small Plot Intensive) farming on prime agricultural soils could generate significantly better yields of food per unit of land area. For example, using expert opinion, my own preliminary estimates based on historical SPIN farming yields, suggest it would be possible to supply 750,000 Edmontonians with 200 lbs. of vegetables (carrots, onions, garlic, beets, chard, etc) each per year with a mere 2,300 hectares of productive agricultural land. Even more hypothetical, if the average Edmontonian ate only vegetables (2,175 pounds per annum) and SPIN farming were used to produce these vegetables, then roughly 25,106 hectares of food land would be required to feed 750,000 Edmontonians; there would be enough (27,860 hectares) of zoned urban agricultural land within Edmonton to meet this demand.[30]

Future trends and policies that could help Edmonton reduce its ecological footprint and become a more sustainable city.

Edmonton, like almost every other Canadian city, depends on material and energy inputs to sustain its current materialist lifestyle. Edmonton's EF has been growing at almost 2% per year since 1981 and shows no sign of slowing down as consumption spending, business investment, exports, imports, and the urban population continue to grow. This suggests that Edmontonians will continue consuming a disproportionate share of the planet's biocapacity, which is neither sustainable nor fair and equitable to other citizens of the world.

[30] These are meant to illustrate a range of possibilities and are thus preliminary estimates that need to be verified and more thoroughly evaluated by those more expert in agriculture and food production.

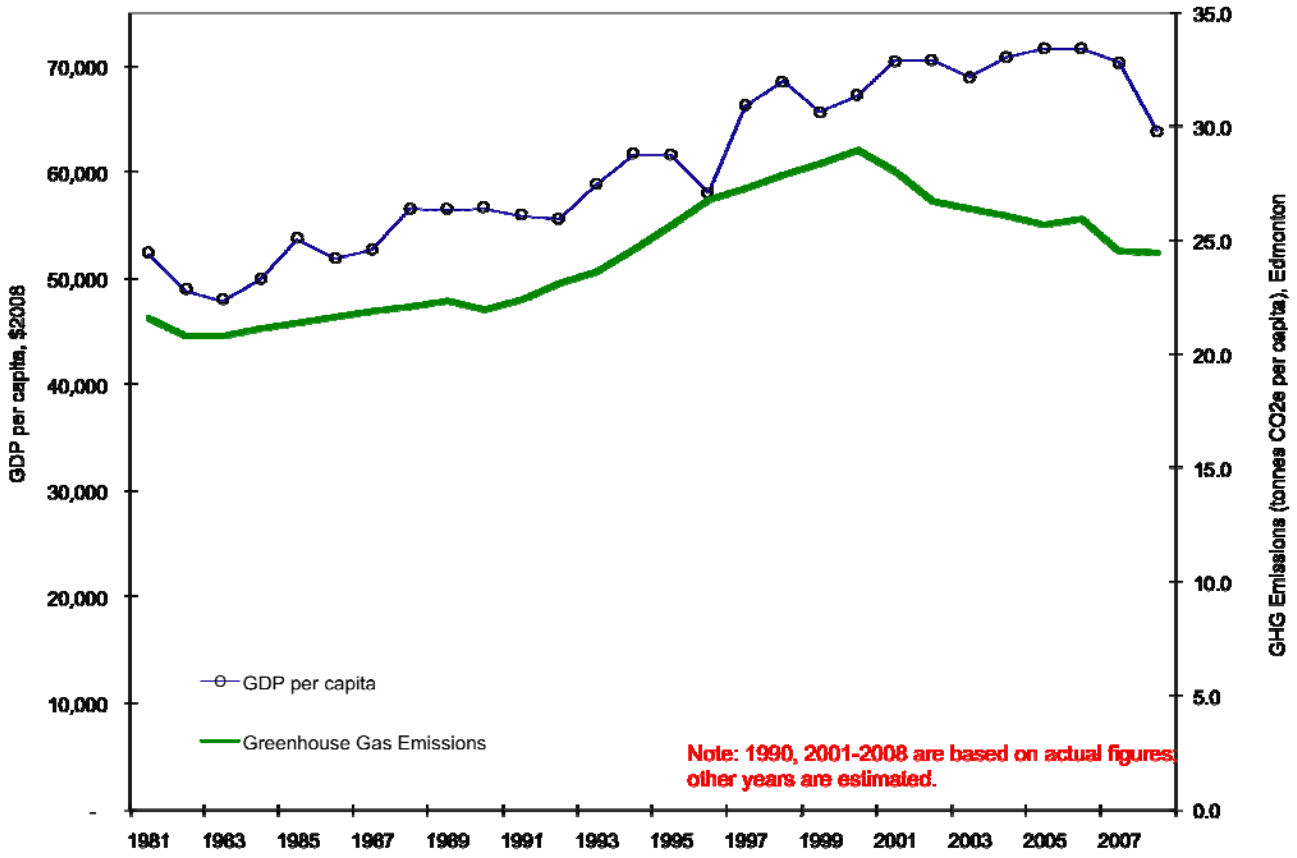
With a world's population already incurring a significant ecological deficit with nature, Edmonton presumably has both an ethical and ecological responsibility to reduce its EF. But what can be done to encourage Edmonton households and businesses to reduce their EF?

Encouraging people to change their current lifestyles will be difficult. While the EF can help educate Edmontonians about the relative footprint size and their relatively inequitable share of the planet's biocapacity, compelling them to reduce their levels of consumption and spending, from an ethical standpoint, will be challenging.

There are, however, many simple lifestyle changes, as previously noted, that when voluntarily adopted would result in a measurable decreased in Edmonton's EF and may actually increase people's quality of life and sense of happiness. Encouraging marginal shifts in behaviour should result in measurable reductions in both energy and material consumption.

The good news is that it would appear that Edmonton's total GHG emissions per capita have been declining (see Figure 3) since their peak in 2000 along with decreasing per capita natural gas and electricity consumption. While it is not clear what factors are behind this positive trend (e.g. improved household energy efficiencies), the result is that Edmonton's overall EF should begin to show a decline given the significance of the carbon footprint component.

Figure 3: Edmonton GHG emissions per capita vs. real GDP per capita, $2008



Source: Anielski Management Inc. (2009). The Edmonton 2008 Genuine Progress Indicator Report, prepared for the City of Edmonton

It would be unreasonable to expect that the City of Edmonton's ecological footprint, both in total area and per capita, could ever be in harmony with the available local biocapacity of the geographic area of Edmonton. Urban communities will continue to depend on imported natural assets. However, it may be reasonable to expect that some major rethinking of Edmonton's long-range municipal development plan, transportation plan, and economic development policies that consider the possibilities such as a sustainable local food production strategy. In addition, every City of Edmonton department could explore options for encouraging households and businesses to achieve ecological efficiencies (i.e. living off less materials and energy) in the area of energy, food and transportation while ensuring ecological resilience of the available natural capital assets of the watershed in which cities are located.

Efficiency gains could be achieved at the margin of changes in residential energy consumption, increased local food production, reduced commuting times and changes in transportation modalities. These efficiencies could be encouraged by policies and regulations established the City of Edmonton. For example, policies and building standards for genuinely sustainable homes (e.g. net zero home building standards or retrofits of existing housing

stock towards net-zero standards) similar to the LEED standard for buildings [31] could be established that would significantly reduce Edmonton's carbon footprint.

Overall, a watershed-based approach to land and water planning and management would be required with the support of a total capital accounting system that included accounts for land, built capital and human capital. For example, pursuing local food production opportunities would require an account of available food land, an analysis of its potential yields under various management scenarios, and an assessment of demands for meeting healthy dietary requirements of citizens. A shift in how the City of Edmonton views agricultural land, as an asset on its balance sheet, would be required. This will also require a practical analysis of import-substitution options available from local biocapacity and human capital.

The truly sustainable city will ultimately be defined by it's capacity for economic and ecological resilience, economic and ecological efficiencies, reduced dependency of carbon-intensive energy, food, materials, goods and services, and ultimately higher levels of well-being and happiness.

[31] Leadership in Energy and Environmental Design (LEED) LEED AP is an accreditation of professionals whereby a set of standards for the environmentally sustainable design, construction and operation of buildings and neighborhoods have been established.

Appendix 1: Edmonton Ecological Footprint, Selected Data, 1981-2008

	Edmonton EF (gha/capita)	Personal Consumption Expenditures per capita ($2008), Edmonton City	Residential Gas GHG emissions (CO2e tonnes)	Residential Electricity GHG emissions (CO2e tonnes)	Residential automobiles, vans and light trucks GHG emissions (CO2e tonnes)
1981	5.95	18,437	n.a.	n.a.	n.a.
1982	5.72	17,578	n.a	n.a	n.a
1983	5.68	17,451	n.a	n.a	n.a
1984	5.75	17,641	n.a	n.a	n.a
1985	6.06	18,544	n.a	n.a	n.a
1986	6.07	18,600	n.a	n.a	n.a
1987	6.19	18,898	n.a	n.a	n.a
1988	6.38	19,552	n.a	n.a	n.a
1989	6.53	19,903	n.a	n.a	n.a
1990	6.56	19,923	1,470,212	1,323,480	2,678,925
1991	6.37	19,807	n.a.	n.a.	n.a.
1992	6.32	19,733	n.a	n.a	n.a
1993	6.42	20,171	n.a	n.a	n.a
1994	6.59	20,728	n.a	n.a	n.a
1995	6.49	20,696	n.a	n.a	n.a
1996	6.74	20,782	n.a	n.a	n.a
1997	6.93	23,068	n.a	n.a	n.a
1998	7.05	24,917	n.a	n.a	n.a
1999	7.25	22,895	n.a	n.a	n.a
2000	7.42	25,372	n.a	n.a	n.a.
2001	7.57	24,647	1,188,671	1,387,350	2,678,925
2002	7.82	24,371	1,330,538	1,407,739	2,821,714
2003	7.80	25,196	1,303,721	1,595,498	2,657,242
2004	7.86	24,734	1,275,591	1,449,589	2,849,119
2005	7.94	25,014	1,237,492	1,501,164	2,854,424
2006	8.29	26,731	1,248,407	1,551,703	3,089,853
2007	8.55	27,965	1,285,673	1,567,667	3,238,756
2008	8.56	27,948	1,316,933	1,628,732	3,255,585

Source: Estimated by Anielski Management Inc. May 2010. CO2e emissions data is from City of Edmonton, Environment Branch (Gay Woloshyniuk, May 2009).
n.a. not-available.