# Moving UBC Beyond Climate Neutral

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# THE UNIVERSITY OF BRITISH COLUMBIA FOOD SYSTEM PROJECT (UBCFSP)
# Scenario 1


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## Abstract

University of British Columbia (UBC), with its large urban land base, large tracts of ecologically significant lands, and research capacity has the potential to become a climate neutral institution. Common Energy UBC, an emerging network of students, staff and faculty at UBC has begun many campaigns to bring UBC beyond climate-neutral. Through meeting with Nancy Toogood, participating in the roundtable discussions and performing literature review we realized that meat production is one of the most GHG intensive products and there exist very few suggestions to reduce green house gas emissions (GHGE) other than to restrict or decrease consumption. A set of standards can be developed to ensure that food outlets are choosing meat suppliers that use environmentally sound farm practices. Our research focuses on livestock production methods, such as livestock density, types of feed, manure management practices, deforestation and fertilizer use to determine standards. We recommend future study develop a general tool for food service companies to use when choosing producers or suppliers, so that they choose those who emit the least amount of GHG and therefore lessen UBC's contribution to global warming.

## Introduction

The University of British Columbia Food System Project (UBCFSP) has been a perpetual and developing study for the past six years. Unlike any other courses at UBC, it is a collaborative, community based action research project between UBC Food Services, AMS Food and Beverage Department (AMSFBD), the Faculty of Land and Food Systems, and UBC Sustainability Office among other important collaborators.

This paper serves as ongoing research to further examine and to provide invaluable knowledge to the Climate Action Partnership (CAP) movement in shifting UBC beyond climate neutral. While there are several different aspects and opportunities to analyze the UBC food system, this paper focuses on the potential opportunity for UBC food establishments reduce their impact on the environment and work towards beyond climate neutrality. As a group we feel passionate about the topic and our combined individual strengths of the group allow for dynamic discussion and interactive research.

This report begins by reflecting on the UBCFSP Vision Statement as it influences the direction of our research and then outlining appropriate background information for context of the problem. Next we present our research that validate and support our findings. Finally, we discuss these findings by realizing barriers and offer recommendations to stakeholders and future research groups who will bring this project forward in coming years.

**Value Assumptions and Vision Statement**

Value assumptions form the beliefs and attitudes of our group. Our values lie in education and strong communities, supporting local, sustainable farms and methods of food productions. As a group, we hold a weak anthropocentric view: prioritizing human needs, while recognizing the importance of the natural world (Bomke *et al*., 2005). Our values ultimately shaped our research proposal and the recommendations we made in this project.

At the beginning of this project, our group reviewed and reflected upon the seven guiding principles that make up UBC Food System Project's Vision Statement. We agree with the seven guiding principles; however, we find the second point, "relies on local inputs when possible, where inputs and waste are recycled and/or composted locally," to be oversimplified. We believe that issues surrounding the food system are very complex and buying local foods is not the only solution. The statement should promote the use of local, sustainable products when possible. It is possible to have a local, unsustainable farm or an Albertan farm that follows sustainable practices. We believe that the seventh statement, "contains a mixture of imported and local foods that come from socially and ecologically conscious producers to ensure long-term financial viability," correlates with the ultimate recommendation of our project.

## Problem Statement

Dramatic climate change such as global warming can have huge impact on the health of our habitat as well as our society. Global warming is predicted to cause changes to ecosystems that will have long-term possible implications causing sea level rising, glacier retreat, arctic shrinkage, change in agriculture patterns, tropical disease expansion, and species extinction (Nature Conservancy, 2008). The three major anthropogenic greenhouse gases are carbon dioxide, methane, and nitrous oxide. Greenhouse gas emissions have gone through dramatic increase over the past three decades (80% increase in $CO_2$ emission and 70% in other greenhouse emissions) and are expected to continue rising in the future decades (IPCC, 2007).

GHG are created and emitted by many activities integral to the functioning of human society, such as electricity, flights, fleets, transportation, constructions, operation of buildings, and agriculture practices (Ferris & Best, 2007). Many of these contributors on climate change are evident here at UBC, which emits 82 750 tonnes of $CO_2$ through building operations, commuter traffic, and flights alone (Ferris & Best, 2007). The less direct contributors such as the production of food products purchased by UBC are more difficult to quantify, but should still be subjects to awareness. The university has made efforts in reducing climate impact from GHG emission through the development of Climate Action Partnership, which is a participatory partnership aimed to move U.B.C beyond climate neutrality. Our role in this project is to provide our knowledge from the field of food related professions and come up with tangible mitigation proposals in the food system component that can be beneficial to UBC's effort.

## Background Information

*Linkages between Climate Change, Food Systems and UBC Campus*

UBC has a large campus that contains many food service outlets that are run under two main operations, UBC Food Services and Alma Mater Society Food and Beverage Department (AMSFBD). UBC Food Services supplies the campus residences with food for students on meal plans as well as various catering contracts and licensing franchises. AMSFBD consists of many different food service outlets contained within the Student Union Building. These range from a sushi outlet to a burger bar.

In addition to these food providers there are others near campus such as franchises and a small grocery store in the village beside campus. In our study we took UBC's food system to be a smaller version of the larger, North American food system. The UBC food system is a system that contains many outlets supplying prepared food and few grocery stores that supply consumers with food to prepare to eat themselves. Therefore our focus is on the suppliers' that food outlets use when making their large purchases of products to sell as prepared snacks and meals make up the majority of food bought on campus.

In order to investigate the effect of food on climate change, it is necessary to assess the level of locality and sustainability of UBC food providers to measure GHG emission on campus. We need to know the country and region where the food on campus is from, the environmental conditions for the products to grow, the level of industrialization and size of farm where the food is grown, how the food is packaged, and how the waste is disposed. All the above will help us estimate the GHG emissions and how far the food travels to UBC campus. According to Ball (2005) transport from farm gate to retailer accounts for roughly 80% of environmental externalities incurred during production and transportation to the retailer.

In addition, the type of food we eat on campus can have a huge impact on climate change. Through talking to Nancy Toogood, manager of AMSFBD, we know 100% of the chicken and bread sold on campus is bought locally, most of eggs are bought locally and most of the beef, turkey and veal are from places outside of BC, but within Canada. To reduce GHGE, we need to control the amount of GHG intensive foods, such as meats and rice sold on campus (Capyk, 2007).

In an effort to purchase and sell more locally produced food, AMSFBD collaborated with AGSC 450 and UBC farm to create the Butternut Squash Pizza at Pie R Squared. In addition, it was estimated that vegetable pizzas comprised 33% of total pizza offerings in 2007. This shows a decreased dependence on animal products. UBC farm now has connections with many food caterings on campus, such as Sage Bistro, Sprouts, Agora, Pie R Squared, The Pendulum, Bernoulli's Bagels. Certain outlets within the UBC food system are attempting to lower their amounts of waste. In AMS food catering, all waste that is generated before consumers receive the food is composted or recycled when possible. All AMS food outlets are involved in a comprehensive composting program which includes all pre-consumer and post-consumer composting of organic food matter and some disposable food containers. The Ecotainer cup is an alternative to standard disposable coffee cups as it can be composted. In addition, AMSFBD offers discounts and promotions to students who bring their own cups and containers for use when purchasing food and beverages from their outlets.

*Global Warming and Livestock Production*

Global warming is caused by an increase in concentration of three major GHGs, which are carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) (Koneswaran & Nierenberg, 2008). Amongst the three types of GHGs, $CO_2$ is most often discussed due to its significant impact on the global temperature (Koneswaran & Nierenberg, 2008). $CO_2$ also becomes the standard of an emission factor, where GHGE are measured in $CO_2$ equivalent (Matthews, 2006). The main causes for $CO_2$ emission are burning of fossil fuels for electricity and production of artificial fertilizer as well as deforestation (Koneswaran & Nierenberg, 2008). Approximately 41 million tones of $CO_2$ are emitted annually through the production of nitrate fertilizer (Koneswaran & Nierenberg, 2008). Approximately 80% of the global soybean crop and more than half of the global production of corn is used to feed the growing population of livestock worldwide (Koneswaran & Nierenberg, 2008). In order to assure the availability of the required amount of feed, overuse of fertilizers is often observed in farms. It is discovered that more than 50% of the total fertilizer applied to the soil ends up in waterways and subsequently the atmosphere (Bellarby *et al.*, 2008). As a result, overuse of fertilizers is considered as the highest direct source of $CO_2$ emissions (Bellarby *et al.*, 2008).

In addition, industrial farming, where livestock are grown in confinement, also cause an annual $CO_2$ emission of 90 million tones to be released in the atmosphere (Koneswaran & Nierenberg, 2008). Increasing reliance on energy-demanding operations, which include heating, cooling, ventilation systems, as well as the production of seed, herbicides, and pesticides, also play a major role in releasing GHG into the atmosphere because more energy sources have to be produced to meet the world's demand (Grillot, 2007; Koneswaran & Nierenberg, 2008). For example, the world's total production of primary energy, such as petroleum, natural gases, coal and electric power, is found to have increased by an average annual rate of 2.4% between the years of 1995 and 2005 (Grillot, 2007). An additional 0.8 million tones of $CO_2$ is also emitted per year because fossil fuels are burned when animal feeds and meat products are transported to various locations (Koneswaran & Nierenberg, 2008).

Deforestation, a significant indirect source of $CO_2$ emission, occurs when forests are replaced by agricultural land in the purpose of growing livestock and animal feed, such as corn and soybeans (Bellarby *et al.*, 2008). It is estimated that an annual removal of approximately 25,000 square kilometers, which is equivalent to 6 million acres of the Amazon rainforest, is needed for grazing cattle and producing animal feed (Sustainable Table, 2003). The soil in forests demonstrates how carbon sinks can store twice as much $CO_2$ than vegetation covers or the atmosphere can (Koneswaran & Nierenberg, 2008). With the removal of forests, carbon sinks are consequently removed, thereby resulting in a release of stored carbon from the soil and into the atmosphere (Bellarby *et al.*, 2008). Soils that are cultivated are discovered to have the ability to release up to 28 million tones of $CO_2$ each year (Koneswaran & Nierenberg, 2008).

Livestock is also an important source for the greenhouse gas emissions. Industrial raised livestock directly and indirectly emit 40% more greenhouse gases and consume 85% more energy than organic raised livestock (Koneswaran & Nierenberg, 2008). Industrially produced livestock is raised in limited spaces, also known as “landless” facilities, where only a small amount of manure is required to be used as fertilizer (Koneswaran & Nierenberg, 2008, p.7). Excess manure is often deposited to a “small, local landmass” where it accumulates in the soil and emits methane, phosphorus and other types of pollutants (Koneswaran & Nierenberg, 2008, p.9). It is measured that approximately 18 million tones of methane are emitted in the United States per year by manure of livestock (Koneswaran & Nierenberg, 2008). Moreover, nitrous oxide is also emitted once manure and urine from the livestock accumulates on the soil (Koneswaran & Nierenberg, 2008). The emission level of methane and nitrous oxide is greatly influenced by the amount of livestock, quality of the animal feed, as well as digestive efficiency and exercise of the livestock (Koneswaran & Nierenberg, 2008). Due to current growing demand for meat in developed countries (Jensen, 2006), the concentration of both methane and nitrous oxide emitted is expected to increase.

*Climate Change in Relation to Global Food Security*

Every food system strives to achieve or maintain food security. Food security is defined as “a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” (Schmidhuber & Tubiello, 2007, p. 19703). Food security can be affected by climate change in various ways. Firstly, climate change affects the production of food and its availability by expanding the types of agricultural pests present and allowing more pests to survive through winter (Schmidhuber & Tubiello, 2007). With a greater population of stronger pests, the higher the risk of crop failure thereby lowering production of food. Food production is also influenced by the $CO_2$ concentration in the atmosphere. Higher $CO_2$ concentration increases the amount of crops yield, yet the nutritional quality, such as protein concentration, may decrease (Schmidhuber & Tubiello, 2007).

Secondly, climate change causes more fluctuations in weather conditions in developed countries and intensifies the weather conditions in the areas that are already subject to high climate variability (Schmidhuber & Tubiello, 2007). Droughts and floods are common examples of climate variability. Increase in climate variability causes fluctuations in food production, which results in instability of food production and exacerbates risks of hunger and diseases in developing countries like Sub-Saharan African and South Asia (Schmidhuber & Tubiello, 2007).

The safety of food is affected by climate change because higher temperature may increase spreading of diseases, such as malaria (Schmidhuber & Tubiello, 2007). Diseases also worsen starvation, a major problem in developing countries, and make people who are already ill to be more vulnerable to other diseases (Schmidhuber & Tubiello, 2007). Lower labor productivity will also result with spreading of diseases, while the poverty and mortality rate increase (Schmidhuber & Tubiello, 2007). In addition, more frequent food poisoning outbreaks may occur as temperature increases because warm temperature supports growth of microorganisms (Schmidhuber & Tubiello, 2007). For example, when the temperature increases and the sea becomes warm, seafood will be unsafe to consume because of the increased risk of shellfish and reef-fish poisoning (Schmidhuber & Tubiello, 2007). Since global climate change has major impacts on food security worldwide, minimal changes should be made to our environment, thereby maintaining the availability of all food products and ensuring that all foods are safe to consume.

*Summary of Climate Neutral Efforts by North American Campuses*

The American College and University President Climate Commitment (ACUPCC) is an initiative to raise awareness for global warming and provides framework and support for schools to become climate-neutral. Universities have a unique role in society: commitment by universities will accelerate the development of new technologies, strategies and solutions to tackle global warming (ACUPCC, 2007). Universities that commit to carbon neutrality must complete an emissions inventory, and within two years they must set a target date and create a comprehensive list of steps and goals to reach carbon-neutrality. Signing schools must take immediate steps to reduce greenhouse gas emissions by participating in short term actions. The pledge also states that schools must integrate sustainability into the curriculum. Lastly, a publicly available plan of action is required by each signing university (ACUPCC, 2007).

The College of the Atlantic was the first school in North America to pledge carbon neutrality and within fifteen months, the school achieved its' goal. The college has minimized and offset green house gas emissions by decreasing the amount of fossil fuels burned as a result of campus activities. The college plans to decrease emissions generated by student travel to and from campus, as well, there are plans to purchase more wind power than any other school in the country. In partnership with The Climate Trust, an Oregon non-profit carbon offset provider, the college's offset purchase is the optimization of traffic signals in Portland, Oregon. This five year project aims to decrease carbon dioxide emissions from idling and accelerating; thus, over the length of the project 189,000 tones of emissions are expected to be reduced (College of the Atlantic, 2007).

At Middlebury College students host energy saving contests in student housing by turning down thermostats and turning off lights, students have also increased the use of public transportation to and from campus. In 2004 the school established a long term plan to purchase local, sustainable and renewable forms of energy, such as wood chips, to supply the biomass plant and to heat and cool the campus' air and water (Middlebury, 2007). By switching to biomass for heating and cooling, Middlebury projects a carbon dioxide reduction of 60% (Middlebury, 2007). To raise awareness of carbon neutrality and steps that need to be taken, school administrators and students have formed the Carbon Neutrality Advisory Group (CNAG) (Middlebury College, 2007). CNAG has made a written proposal on the costs, risks and impact of achieving carbon neutrality by 2016.

Evergreen State College in Washington plans to be carbon neutral and a zero-waste facility by 2020. The school has an organic farm that produces enough food to supply the campus food service: the goal is to increase locally produced food purchases to forty percent by 2010 (ESU, 2007). Food waste is deposited into food-scrap bins which are located in each building and residence on campus. Waste is then transferred to Evergreen's massive compost site. Students have also agreed to pay an extra fee in order for the school to rely one hundred percent on green energy, such as geothermal power and wind power (ESU, 2007).

From 1980 to 2000, Cornell University has implemented substantial and successful efforts to reduce campus energy consumption (Cornell, 2006). Reducing energy use saves money for other uses within the university operating on the three pillars of sustainability. At Cornell, air conditioning is supplied by Lake Source Cooling. The Lake Source Cooling Project utilizes a renewable resource, the deep cold waters of nearby Cayuga Lake, and saves 90% of the energy required by the old conventional chiller system (Cornell, 2006). The Lake Source Cooling Project reduces campus electricity purchases by 10%. In addition, Cornell encourages community members to turn off and unplug electronic equipment over holiday breaks. In the 2003 13-day holiday period, Cornell saved $75,000, which is equivalent to turning off 37,000 computer monitors and 50,000 two lamp fluorescent fixtures (Cornell, 2006).

Oberlin College has put advances in computer technology to good use by setting up a real-time energy and water monitoring system. Because of this technology, students have the ability to monitor their consumption and change their consumption habits. In addition, every new building on campus must be built in accordance with the US Green Building Council's Leadership in Energy and Environmental Design (LEED) silver standard (Oberlin, 2007): every aspect of the building's infrastructure and functions are maximized for sustainability.

Similar to Oberlin College, Harvard University has put in place a set of green building requirements: every new building and all renovations must be up to LEED silver standards or higher (Harvard, 2002). As well, there a number of sustainability principles have been made: decrease waste and use of hazardous materials, increase the use of renewable resources, increase the diversity of native species in order to enhance the health of campus ecosystems, and establish indicators of sustainability to allow monitoring and improvement.

*Roundtable Discussion – Summary*

The roundtable discussions are an initiative of the previously mentioned Climate Action Partnership (CAP) at UBC. The goal of the various roundtable discussions is to put together a document outlining the strategies UBC will put forth to reduce GHGE and climate change at both the Point Grey and Okanagan campuses (CAP SC, 2007). There will be nine roundtable discussions in total that include different climate-related areas including food, waste water, energy and others (CAP SC, 2007).

Many different stakeholders and experts came together to participate in the food roundtable discussion. These included representatives from Common Energy UBC, employees in charge of Waste Management at UBC, various professors, Alma Mater Society (AMS) members, various UBC students and others (NOTES).

There were four different questions that were addressed during the food roundtable.

1. We know much better how to reduce emissions than we do how to measure them. What food items known to have lower emissions can be provided in the short run by UBC food providers?
2. What does a Beyond Climate-Neutral Food System look like at UBC?
3. What are the targets and indicators that we can set for a beyond climate neutral food system?
4. What are some food system best practices (at UBC or elsewhere)? What current opportunities do we have for immediate and long term action? How can we act on this?

The ideas that were put forth from the discussions about question 1 were centered on GHGE associated with different foods and waste management. Different problems were identified within these two main ideas and then possible solutions were suggested. In several discussions it was mentioned that beef has very high GHG emissions associated with it and also that wetland agriculture can contribute to GHG emissions. The types of preservation and transport were discussed and the ideas put forth were that frozen foods are more GHG intensive than foods that were canned, fresh or dried and also that plane transport was worse than some other methods of transporting food.

One suggested solution was that as a UBC research initiative foods should include information on the amount of GHG gases or carbon inputs that were needed to produce, transport and process that item. This information could help people and businesses focus on lower GHGE foods. Another suggestion using this system was to possibly have businesses use offsets if they served a lot of GHG intensive foods.

Another solution could be to present ideas for reducing the amount of GHG emissions associated with food to outlets at UBC at the time of contract renewals so that when the businesses renewed business with UBC it was under the condition that they operated in a less GHG intensive manner.

Compost was discussed as being an area of food waste management that could be improved to lower GHG emissions. Some problems with compost that were identified are the energy inputs to run the composting at UBC, there are not composting bins in all food outlets on campus, people do not know what can be composted and there are emissions from the composter.

For question 2 the main themes were increasing consumer awareness of the GHGE associated with food, building on the initiatives in place already to lower GHGE, and the importance of having proactive policy and administration towards climate neutrality and beyond it.

Businesses will cater to whatever demands the consumers make so it is important to shift consumers towards consumption of lower GHGE. Having UBC be a vocal leader in sustainability will increase knowledge of GHGE-related issues among students, staff, and faculty.

Initiatives that could be built upon included expanding the amount of food produced on campus through the UBC farm, rooftop gardens and planting fruit trees.

A proactive policy suggestion for franchises on campus was to have specific policies on GHGE reducing practices that all food outlets at UBC must follow. Another idea was to phase out any food flown in by plane. Having composting bins at every building on campus was another idea for a useful policy.

It was mentioned that it would be extremely important to have leaders and champions in the UBC administration that are committed to creating a more sustainable campus that was eventually beyond climate neutral.

In question 3 several targets and indicators to monitor whether or not we are meeting targets were suggested.

First was the concept that increasing the amount of local food sold on campus would decrease the GHG emissions associated with the foods.  The indicator for this would be what the baseline percentage of local foods sold on campus was and increasing this percentage a certain amount over a period of time.

Secondly the matter of unsustainable farming practices, such as tillage, was discussed. The target would be to reduce the amount of unsustainably grown food and could be monitored by setting standards for how much food sold at each food outlet can be produced in unsustainable ways.

The third target was to reduce the energy used for refrigeration by measuring the amount of electricity and fridge space being used.  Using more efficient appliances was another target with the indicator being electricity usage.

Consumer acceptance of changes to food availability on campus is important. Monitoring and increasing consumer acceptance is another target.

Finally one more target was to have all food that can be composted or recycled placed in the proper system.  Indicators for this could include monitoring the amount of recyclables in the waste system or monitoring the amount of compost the UBC composter is creating.

Problems and solutions to do with longer-term food system sustainability at UBC were discussed in question 4.  It was mentioned that recycling is not the only answer and there are ways to decrease GHG emissions before getting to the recycling step and also that the discount given at UBC outlets for bringing your own container is too small.

Suggestions for solutions included making containers brought from home mandatory, having strict purchasing policies concerning sustainability of food sources and phasing out the most unsustainable foods on campus.

Other ideas included increasing the green space and food producing land on campus. In the long term fuel will be scarce to transport food in from further away. Promoting seasonal menus and educating people to buy their groceries more often so they can choose less packaged and processed foods could do this.

Finally it was suggested that a system of incentives and penalties could help to change behaviors.

**Research**

The main recommendation contained in this paper is a long term goal aimed at evaluating the meat producers that UBC food service outlets use. The goal is to eventually compile a list of standards to consider when choosing a livestock producer. By having a set of standards to check when choosing livestock producers, in order to identify those with lower GHGE, UBC food providers can still satisfy consumer's preference for meat products while lessening the impact on climate change. In addition UBC would be supporting those producers that are raising their livestock in a more ecologically sound manner which could help ensure that they continue producing successfully that way. If UBC advertised their strategy for who they choose to buy meat from and why, it would potentially raise awareness to consumers of the true environmental cost of the meat products they consume, beyond that of emissions caused by travel.

Many of the suggested solutions to reducing GHGE from meat production and consumption include varying degrees of restricting meat intake. While this would help reduce the amount of animals being produced it would also be effective to source and support livestock producers that create less emissions by altering their production methods. By combining reduced consumption with lower GHGE produced meat products there could be a significant reduction in the GHGE caused by meat production and consumption and consumers could still eat meat if they prefer. This recommendation to analyze producers will hopefully be more realistic for restaurants and food providers since it can be detrimental to business to change products without the support of consumer preference, and simply removing meat products from the menu may not be an option for all food service outlets.

Nancy Toogood, the manager of AMS Food and Beverage, confirmed that there is no system in place for evaluating meat producers used by AMS food service outlets. She also revealed that most of the meat products bought by AMS Food and Beverage are purchased from Neptune, and sometimes from Centennial Meats. AMS is not under contract to continue to buy from these suppliers. Therefore if new sources could be identified it is feasible that AMS could begin buying from them.

While $CO_2$ is often thought of as the main GHG methane is also a very significant GHG. When considered in terms of their potential to trap heat and warm the atmosphere methane has a heating potential 21 times that of carbon and nitrous oxide's heating potential is even greater at 296 times that of carbon (Koneswaran & Nierenberg, 2008). So by focusing on reducing the emissions due to livestock production has the potential to reduce the GHGE greatly that are due to the food system.

This paper's evaluation of GHGE is restricted mainly to beef production as well as some dairy farm and pig farm analysis. Overall the farm management practices we identified as being significant to GHGE from farms were: manure handling practices, types of feed used, livestock density, deforestation and fertilizer use.

*Deforestation*

Forests are one of the most valuable eco-systems in the world, containing over 60% of the world's biodiversity. The Food and Agriculture Organization (FAO) estimates that forest cover in Central America will be reduced by 1.2 million ha until 2010, in South America forest area will decrease by 18 million ha (Fearnside. & Laurance, 2004).

Expansion of livestock production is a key factor in deforestation, especially in Latin America where the greatest amount of deforestation is occurring: 70% of previous forested land in the Amazon is occupied by pastures (Fearnside & Laurance, 2004). Statistics from less than a decade ago indicate that 15,000 $km^2$ of forests are used expressly for the purpose of cattle grazing (Koneswaran & Nierenberg, 2008). In some places the government often chooses cattle over other options because cattle have low maintenance costs and are highly liquid assets easily brought to market. Additionally, cattle are a low-risk investment relative to cash crops which are more subject to wild price swings and pest infestations.

Deforestation accounts for 9% of anthropogenic $CO_2$ emissions, most of it due to expansion of pastures and arable land for feed crops (Fearnside & Laurance, 2004). The consequences of deforestation on local and global climates are through disruption of carbon and water cycles (Buschbacher, 1986). Forests act as a major carbon store because $CO_2$ is taken up out of the atmosphere. When forests are cleared the area releases stored $CO_2$ and can no longer act as a carbon sink.

Protected areas, indigenous land rights and restrictions on cattle in buffer zones of protected areas can be effective in limiting deforestation, but only where there are sufficient resources and political power to enforce these policies. Governments must decide which public lands they do not want to pass into private hands and strictly enforce those decisions, and the incentives must be eliminated for clearing forests to claim land and improve tenure security (Kaimowitz, 1996). These governments cannot be realistically expected to maintain control over all current public lands, but they should attempt to keep control of priority areas.

*Livestock Density*

A management practice of livestock production that can result in different levels of GHGE, depending on the method employed, is livestock density. Livestock density has to do not only with how many head of cattle there are but often also with the amount of land that is available per head. Along with livestock density, the choice between organic versus conventional farming methods becomes relevant as outputs from organic farms are generally much less than from conventional systems (Subak, 1999). While there are many studies exploring the topic of tracking agricultural GHGE and the effect of different farming methods it is difficult to accurately examine and quantify the emissions due to the many different, varying systems and variables and the flux that can occur over time in these systems (Olesen *et al*., 2006). In spite of this several models have been suggested to attempt of quantify and compare emissions from different farm systems.

An increase in livestock density is found to increase the net emissions of $CO_2$ and ammonia as well as the nitrogen and other pollutants that come off the farm (Subak, 1999). A higher nitrogen run – off as well as higher fuel and fertilizer inputs which result in GHGE when they are put into use at the farm was also found for intensive farm systems (Subak, 1999). The excess nitrogen in the soil due to intensive and conventional farms results in greater N2O emissions (Olesen *et al.*, 2006)

When beef are produced in a feedlot they have 2-3 times the heating potential of the same beef that was produced in a different way. (Subak, 1999). This figure includes consideration that pasture fed cattle may emit less methane. Nonetheless feedlot cattle still contribute more GHG causing global warming due to the inputs needed by the intensive production system.

Intensive systems require more inputs overall to manage the amount of livestock and manure produced. By sourcing meat products, as well as dairy, from smaller farm operations consumers could reduce the GHG emissions that are associated with the meat they are purchasing.

Several studies found conflicting results when comparing GHGE from conventional and organic livestock and dairy farms. This is probably partly due to the variations in size and management of all farms. One case study that compared a conventional and an organic farm of relatively equal size found almost no difference in the amount of emissions from each farm (Flessa *et al.*, 2002). This was largely due to the fact that organically raised livestock takes much longer to reach slaughter weight and so requires more inputs over a longer period of time, as well as possibly contributing more methane emissions (Flessa *et al*., 2002). Many studies reached this conclusion that due to the longer production time of organic livestock they produced GHGE that were comparable to those in conventional farms where production time was much shorter (Dalgaard, Halberg, & Kristensen, 1998; Dalgaard *et al.*, 2001; Subak, 1999). A study that developed a method for calculating GHGE based on nitrogen surplus, calculated the difference between imported and exported nitrogen. They found that there was a relationship of increased nitrogen with increased livestock density regardless of whether the farm was organic or conventional (Olesen *et al*., 2006).

One study found that in organic dairy farms there was less nitrogen surplus and suggested this was because that farm had to utilize nitrogen from the soil and organic manure and so managed this cycle more efficiently (Dalgaard *et al*., 1998).

While organic may not be criteria when choosing meat producers with lower GHGE it is still an important factor to consider. While the difference in GHGE from organic versus conventional farming has not yet been found to be significant other environmental and social factors should still be taken into account as the benefits of organic over conventional farms are certainly not limited to differing amounts of GHGE (Pimentel *et al*., 2005).

*Fertilizer Use*

Corn and soybean are the most common type of animal feed used in factory farms today (Koneswaran & Nierenberg, 2008). The two main reasons causing these grains to become major livestock feeds are their protein-rich contents and low production cost (Sustainable Table, 2003). With an annual production of approximately 10 billion bushels of corn and 2.8 billion bushels of soybeans in 2000 in the United States, 60% of corn and 47% of soy are for livestock consumption (Environmental Protection Agency, 2007). In order to maximize the yields of both corn and soy, artificial fertilizer, also known as nitrate fertilizer, is often applied to the soil (Koneswaran & Nierenberg, 2008). A hundred million tones of artificial fertilizer are produced annually through oxidation of ammonia resulted from the Haber-Bosch process, a reaction that synthesizes ammonia using nitrogen and hydrogen (Koneswaran & Nierenberg, 2008). Although the Haber-Bosch process successfully increases the availability of artificial fertilizers, it is nevertheless an energy requiring and unsustainable method since 1.2% of the world's energy is needed to produce nitrate fertilizer (Wood & Cowie, 2004). This process is also closely associated with the emission of greenhouse gases, where 1951.2 grams and 1491.5 grams of $CO_2$ equivalent are expected to emit for every kilogram of fertilizer produced in Canada and the United States, respectively (Wood & Cowie, 2004). As the world demands for more meat (Jensen, 2006): both the production of grain and amount of livestock increases. For example, the production of corn in U.S. increased from 10 billion bushels in 2000 to 13.1 billion bushels in 2007 (Environmental Protection Agency, 2007; Hargrove, 2008). In addition, the amount of corn used as animal feed increased from 60% in 2000 to 70% in 2007 (Environmental Protection Agency, 2007; Hargrove, 2008). As a result, more artificial fertilizers will be synthesized, hence increasing the emission of greenhouse gases. In order to avoid further exacerbation of current situation, the ideal solution is to produce animal feed organically, since no artificial fertilizers or antibiotics are applied to the soil (Quamut, 2008). Yet, farming organically is often considered as an inefficient method by industrial farms (Quamut, 2008). A more practical solution that our group believes is to establish production quotas for corn and soybeans, thereby restricting the amount of fertilizer used on the soil. Farmers who overused artificial fertilizer will be subjected to a penalty fee. Another solution is to impose a tax on each kilogram of fertilizer used. With a higher production cost, farmers will be more aware of the amount of fertilizer applied and might even discourage farmers to use fertilizer.

*Types of feed*

Feeding cattle high quality legumes and forages can decrease methane production by twenty percent. In particular, the carbohydrates in immature legumes and forages are readily digested in the ruminant gut. Rapid digestion and increased passage of digested feed lead to decreased methane emissions. According to research from the University of Manitoba, grazing beef cows on alfalfa grass pastures compared to grass-only pastures decreased methane production by 25 percent (Boadi & Wittenberg, 2004). As well, grazing cattle early in the season when pastures are still immature decreased methane production by 25-45 percent compared to grazing steers later on in the season (Boadi & Wittenberg, 2004).

Finely ground or pelleted low quality forage increases the efficiency of digestion by cattle. According to the Faculty of Agricultural and Food Sciences at the University of Manitoba, the practice of grinding or pelleting feed lowers fibre digestion and increases feed passage through the digestive tract; as a result, methane production is decreased by twenty to forty percent (Boadi & Wittenberg, 2004).

Ruminants that are fed forage preserved as silage produce less methane emissions compared to those fed forage processed into hay. This decrease in emissions occur as a result of anaerobic fermentation of some carbohydrates in the silo; thus, reducing the amount of fermentation in the rumen.

Adding fats or oils to the ruminant diet decreases methane production by 33 percent with four percent canola oil is added to the diet (Boadi & Wittenberg, 2004). However, too much fat in the ruminant diet decreases fibre digestion. The reason ruminants such as cows are so valuable to humans is because they are able to digest certain carbohydrates (fibre) that humans cannot. As a result, the energy created by digesting the fibre is turned into high quality protein sources such as meat and milk.

Pasture-fed cows release more methane than cows raised and fed in feedlots: lower productivity and longer life spans of pasture-fed cows translate into higher methane emissions. Pastures however reduce carbon dioxide in the air through a process called carbon sequestration, grazing animals also do their own fertilizing and harvesting. When all emissions associated feedlots are taken into account (use of fossil fuel and fertilizers and the loss of carbon sinks), the feedlot system actually produces 1.8 times the amount of greenhouse gases than the pastoral system (Subak, 1999).

*Manure Management Practices*

Effective manure management can achieve a significant reduction in methane production, thereby relieving some of the burden on the climate in terms of animal agriculture. Based on an estimation done in the year 2004, animal manure can release a total of 18 million tones of methane globally each year, which is roughly 4 percent of global anthropogenic methane emissions (US-EPA, 2005). Methane is released during anaerobic decomposition of the organic material present in the manure; a process sped up when manure is in liquid form. Unfortunately, pig operations in most part of the world and dairy operations in North America handle manure in holding tanks or lagoons rather handling them in dry form (Steinfield *et al.,* 2006).

Other than handling it in dry form, many other effective methane reduction practices are also available. Since the amount of methane production is decided by extent of anaerobic decomposition due to bacteria growth, efficient microbe growth inhibition is crucial. Factors that influence bacteria growth include aeration, surrounding temperature, storage time, and energy content (Steinfield *et al.*, 2006). First, agitation and turning would allow more surface area that is in contact with air, resulting in a higher extent of aerobic decomposition (Hao *et al*., 2001). Frequent and complete removal of manure from storage pit and cooling of manure to below 10° C we can achieve up to 50% reduction in emission reduction compared to liquid-slurry phase under warm temperature, while using feed with higher digestibility minimizes waste energy that are available for bacteria growth (Steinfield *et al*., 2006).

**Barriers & Challenges**

1. Livestock producers or distributors, such as Neptune, are not always willing to give out information on their production methods. Therefore it could be difficult to apply these standards to producers in order to evaluate their amount of GHGE.
2. Livestock produced in a lower GHGE way may be more expensive to purchase and not feasible for businesses to switch providers
3. There may be very few producers that operate in a way that lowers their GHGE. While this is a challenge it is also an opportunity because if UBC is a leader in supporting these more sustainable producers this could support their businesses and encourage other producers to follow suit and produce in a lower GHGE way. Eventually this could also lead to lower prices, in the long term.
4. Once standards are identified there may not be enough manpower or interest within companies to evaluate and go through the process of switching providers.

**Recommendations**

*To AGSC 2008 Colleagues*

1. Further our research by talking to vendors that supply meat to UBC (such as Neptune) and find out whether they supply meat that has been raised in a sustainable manner.

2. Conduct further research to determine the farming practices that rely the least on fossil fuels.
3. Do the same type of research done in this paper with a different food group to determine what food production practices have the lowest environmental impact.
4. Find out if there are any local producers that follow sustainable production practices.
5. Compare prices between food producers that are and are not greenhouse gas intensive.

*General Recommendations*

Consumer incentives: pricing and labelling each type of livestock product to reflect the true cost of its production could provide consumers with important information and with incentives for choosing alternative food products.

Subsidies: support sustainable agricultural production. Transfer or reorient current subsidies to support sustainable practices, for example the Organization for Economic Co-operation and Development provided US$283 billion in subsidies for grain production (Tilman *et al*., 2002).

Tax: implement tax on fertilizers or pesticides to discourage excessive use that contribute to emissions (Tilman *et al*., 2002).

*Long Term Recommendations*

Our group has identified many feasible and effective long term recommendations to generate more climate-friendly agricultural practices. We have identified policy change to be crucial for enforcement of necessary action. For example, contracts should be modified to ensure producers / suppliers are responsible for the GHG emissions of their products. This can be done through such implementations as taxation on fertilizer and pesticide use. UBC controlled food service providers should be obligated to purchase local and sustainable meat products. More subsidies to agriculture from the government in support of sustainability are also essential.

We follow by creation of educational programs in both secondary and post-secondary schools. Secondary school farm visits can help raise awareness and interest in the food system and pay attention to the negative impacts improper practices can have on the environment.

**Conclusion**

In reality, many obstacles are present that can potentially prevent or slow down the implementation of the suggested recommendations. To start, policy change can be slow because of complicated and slow moving administration processes. This is followed by possible lack of interests by stakeholders. This can result from a cutback in their profit generation or simply conflict in willingness for a paradigm shift.

However, from the research in this paper it would be possible for students even next year to implement some of our findings.  While there is no specific and quantifiable set of standards if a producer was found that was close by to UBC, who was a smaller producer and stored manure in dry form this could be identified as a possible alternative.  By just taking small steps to support less GHG intensive producers UBC would be lowering the GHGE of part of their food system.

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