Food for Thought

The Issues and Challenges of Food Security

August 2010

Provincial Health Services Authority
Province-wide solutions. Better health.

Prepared for the Population and Public Health Program, Provincial Health Services Authority

Acknowledgements

Researched and written by:
Aleck Ostry, MA, M.Sc, PhD. Canada Research Chair on Social Determinants of Health, Michael Smith Foundation for Health Research Senior Scholar, Professor University of Victoria

Edited by:
Aura Rose, President, Healthwise Communications Inc. and
Jan Enns, MA, Principal, Jan Enns Communications

Resource Team:
Alice Miro - SmartGrowth, BC
Claire Gram - Vancouver Coastal Health
Clifford Stainsby
David Coney and staff - Ministry of Agriculture and Lands
Deepthi Jayatilaka - Provincial Health Services Authority
Grant Sheppard - Ministry of Education
Heather Deegan - Interior Health
Dr. John Millar - Provincial Health Services Authority
Marylyn Chiang - Union of BC Municipalities
Meghan Day - Ministry of Healthy Living and Sport
Pam Christenson - Ministry of Social Development and Housing

For further information, contact
Deepthi Jayatilaka
Provincial Manager, Food Security
Provincial Health Services Authority
700-1380 Burrard Street
Vancouver, BC
V6Z 2H3 Canada
www.phsa.ca/populationhealth (Food Security)

PHS-003-027

Table of Contents

Overview

Food is a key determinant of health. It is clear that the quality and quantity of the food we eat affects our health. And our health is critical to productivity and prosperity. Today in British Columbia not everyone has access to enough nutritious and safe food. How food is produced, processed, distributed and marketed, our income and where we live all impact our food choices. While education on eating healthy is important, so is the removal of systemic barriers to healthy eating. The range of actions that fall under the phrase "food security" aims to address these barriers. Based on evidence of the relationship between food security and health, food security is now a key public health priority in British Columbia (BC).

The purpose of this research volume is to shed light on a number of issues that affect the food security of British Columbians. The goal is to provide easy access to current evidence sourced from peer reviewed research and other credible publications, to inform the development of programs and policies that address these issues. The research material is presented in seven chapters.

Chapter One provides the evidence related to affordability of nutritious food. Issues covered include income as well as housing and food costs. For example, BC has the most expensive housing in Canada which means that less money is available to purchase food. Expensive housing reduces food security.

Chapters Two through Five examine an emerging challenge to food security – climate change and its effects in BC and around the world. As the climate changes, so will the food we can grow and the food we can import. We need to understand not only how climate will affect food grown in BC and abroad but also how BC agriculture and food imports can affect climate change – to plan for our future food security.

Chapters Six and Seven present evidence on how the built environment, that is the physical organization of our communities, can create places that make "healthy eating the easy choice." For example, today in BC there are at least 170 community gardens. And initiatives underway since 2005 are changing the food environment within BC schools, recreational facilities and public buildings. But more can be done to advance these helpful shifts and this is the research that is examined in these last two chapters.

It will take all of us – communities, businesses, community organizations and governments – working together to achieve food security for all. We hope that the research presented in this volume will inspire readers to learn more and take action.

Defining Food Security

The Food and Agricultural Organization of the United Nations states that food security "exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life." To achieve food security, all four of its components must be present. These are:

- availability of food, being the quantity of food available for a given population;
- stability of supply, meaning how reliable the food source is over time;
- accessibility of food, indicating the ease with which a population may obtain available food; and
- utilization of food, representing the cultural and culinary acceptability of the food, as well as the extent to which people have the skills to properly utilize it.

Research Methods

In order to gather and examine the most recent research available on topics salient to food security in British Columbia, a series of literature searches were completed using a basic set of keywords to identify major papers published in areas linking food security and health, economic well-being, climate change and the built environment. Once identified, articles were selected for perceived relevance based on title and imported into the database. Each abstract was then examined for relevance. Well over 500 articles were reviewed for this report. These can be found in the reference sections of each chapter.

Chapter One: Food Security, Economic Well-being and Health

Several recent national surveys have explored food security in the Canadian population and its links to economic well-being. They show that those earning a lower than average income may spend a greater percentage of their income on housing, having less left over for food. For these low-income earners, both the cost and availability of nutritious foods can be a barrier to healthy eating.

This chapter examines the relationship between income, food security and health by reviewing the evidence related to cost of eating nutritious food; the links between housing and food security; and barriers to accessing nutritious food in lower income neighbourhoods. While the issues are complex, proactive initiatives taken by businesses, all levels of government and other agencies can help to improve the food security of all BC residents. Information provided in this chapter is meant to inform policy and program decisions and actions.

The Relationship between Income and Food Security

Since the mid-1990s, several national population health surveys have demonstrated a clear linkage between income and food security. Consistently these surveys show that as the adequacy of household income deteriorates, the likelihood that a household will report some experience of food insecurity increases dramatically (Kirkpatrick and Tarasuk, 2008b; Health Canada, 2007; Tarasuk et al., 2009; McIntyre, 2003; McIntyre et al., 2000; Vozoris and Tarasuk, 2003; Che and Chen, 2001).

In the 2004 Canadian Community Health Survey[1] (CCHS 2.2), 9.2 percent of Canadian households reported food insecurity, with this prevalence rising to almost 50 percent in the lowest income group (Health Canada, 2007). Households were considered to have severe food insecurity if they reported disrupted eating patterns and reduced food intake among any household members. According to the CCHS, in 2004, 2.9 percent or 353,700 Canadian households were severely food insecure. Among the lowest income group, 25 percent reported severe food insecurity (Health Canada, 2007).

While the extent of food insecurity among lower-income groups varies, studies show that within the lowest income group three sub-populations (not necessarily mutually exclusive) are at particular risk:

- single parent families headed by women;
- aboriginal peoples, particularly those living on reserves (Lawn and Harvey, 2003, 2004a, 2004b); and
- marginally housed and homeless people (Tarasuk et al., 2009; Hagan and McCarthy, 1997; Hamelin et al., 2007; Khandor and Mason, 2007).

1 The CCHS is the most comprehensive and representative survey of the health status of the Canadian population. Nevertheless, it must be noted that the survey methodology has limitations.

The Cost of Eating in BC

Since the year 2000, the Dietitians of Canada, BC Division, has priced the cost of a nutritious food basket in various communities in BC. Until 2007, convenience sampling was used to select grocery stores within various regions in order to estimate food costs. In 2007 the Dietitians of Canada moved to a more robust sampling technique to better estimate the cost of food for families. The National Nutritious Food Basket is a tool developed by Health Canada that describes 67 food items and the quantities that represent a nutritious diet for a variety of individuals.

The content of the food basket changed in 2008 to reflect current nutrition recommendations and purchase patterns of Canadians. The food basket includes 67 basic foods, but does not account for any special dietary needs, differences in activity levels or cultural food choices. The basket excludes take-out or restaurant meals and any non-food items, such as personal care or household supplies (Dietitians of Canada, 2009).

In 2009 food costing was conducted in 134 randomly selected grocery stores throughout BC. This sampling indicated that the provincial average for the cost of a nutritious food basket, for a family of four (two parents, two children), was $872 a month. There were large regional variations, with the highest cost ($919) found in the Vancouver Coastal Health region and the lowest ($835) in the Interior Health region. Since the Dietitians of Canada changed their sampling methods in 2007, and then the food basket changed in 2008, it is difficult to determine whether the cost of the food basket has changed since 2007. However, the changes made to the tool and methodology and continued collection of data will help to more accurately monitor the cost of a nutritious food basket in future years.

The Cost of Housing and its Effect on Food Security in BC

The impact of provincial housing costs on disposable incomes, and therefore on food security, is important to assess.

In Table 1 (http://www.dietitians.ca/pdf/CostofEating2009_revJan10.pdf) of their 2009 report (pg. 5) the Dietitians of Canada factored in average housing costs along with average costs of nutritious food baskets for families at various levels of income. This table shows that a BC family of four with a single wage earner on median income (based on 2006 median income in BC of $53,892/yr) would spend about 19 percent of their income on a nutritious food basket. A family of four with a single wage earner on low-income ($29,496/yr) would spend 35 percent of their income to purchase the same food basket. And, a family of four on income assistance ($21,276/yr) would spend 49 percent of their income to purchase this food basket. The 2005 Provincial Health Officer's Annual Report concluded that food insecurity in BC was higher than the national average. The Report suggested that these higher rates were attributable to a higher concentration of low-income families in BC and growing problems of housing affordability. The report pointed out that housing in BC is generally more expensive than in many other parts of the country. High housing costs were diverting increasing proportions of household incomes to accommodation costs, reducing income available for the purchase of food (Provincial Health Officer, 2005).

When housing costs are high, people who are food insecure will often choose cheaper, unhealthy foods because it gives them a higher caloric intake (Provincial Health Officer's Annual Report, 2005). The trend of

increasing house prices and rents in BC in combination with accelerating food price inflation, are both factors leading to further increases in housing-related food insecurity.

The situation for the marginally housed and homeless may be more dire. As noted in Chapter Six *Built Environment, Food Security and Local Government*, homeless people may not have facilities to prepare or store food made available by food assistance programs (Hickey and Downey, 2003; Eikenberry and Smith, 2003; Hickey et al., 2003). The lack of a permanent address may disqualify the homeless from some food assistance programs while their lifestyle can affect access to programs that serve food only at very specific times (Eikenberry and Smith, 2003). When purchasing food, homeless people may be limited to stores located in their immediate vicinity, limiting opportunities to acquire healthy food (Hickey and Downey, 2003). Furthermore, homeless people may opt to purchase items based on mitigating hunger rather than on overall nutritional value (Hickey and Downey, 2003). Finally, the homeless often have difficulty finding safe, comfortable places to eat the food they obtain (Hickey and Downey, 2003). Gaining access to a steady supply of clean and safe drinking water to ward off dehydration is also a challenge.

Physical Barriers to Accessing Food

The barriers to consuming nutritious food can be both economic and physical. Studies conducted over the past decade have shown that access to nutritious, affordable food is often better in neighbourhoods with a large proportion of high-income earners and highly educated people (Larson et al., 2009). Lower-income neighbourhoods have fewer food outlets offering more nutritious food compared to higher-income ones; and have a higher proportion of both people who are obese and people with poor health (Papas et al., 2007; Moore et al., 2008; Story et al., 2008; Wang et al., 2008).

While the lack of local food outlets can impact access to affordable and nutritious food, so can the absence of reliable transportation options (Holben et al., 2004); in both rural areas and lower-income urban neighbourhoods under-served by public transport (Sharkey and Horel, 2008). This problem is more acute in rural areas (Sharkey and Horel, 2008), in northern communities (Ledrou and Gervais, 2005) and among aboriginal peoples living on reserves (Lawn and Harvey, 2003, 2004a, 2004b). Research from Australia suggests that access to adequate private transport had a greater effect on food access than did physical proximity to food stores (Coveney and O'Dwyer, 2009; Sharkey, 2009). For a far greater discussion on how community planning and neighbourhood design can affects food access, see Chapter Six.

Food Insecurity, Nutrition, Income and Health

Studies conducted in Canada show that people who are food insecure tend to have very low intakes of fruits, vegetables and milk products (Glanville and McIntyre, 2006; Kirkpatrick and Tarasuk, 2008a; Li et al., 2009; Tarasuk, 2001b). While adults and adolescents in food-insecure households are at increased risk of inadequate nutrient intakes, children's intakes appear to be less affected (Kirkpatrick and Tarasuk, 2008a) – a finding consistent with reports that adults restrict their own food intakes in order that their children might eat better (Hamelin et al., 2002; McIntyre et al., 2003; Radimer et al., 1992).

Within food-insecure families, the quality and quantity of women's food intakes deteriorate as household resources dwindle (Tarasuk et al., 2007). Individuals in these households are more likely to report poor or fair health, poor functional health, restricted activity, multiple chronic conditions, major depression and distress

and poor social support (Vozoris and Tarasuk, 2003; Che and Chen 2001). This finding is supported by the World Health Organization's (WHO) report on social determinants of health entitled *Closing the Gap in a Generation* which states: "health inequity is caused by the unequal distribution of income, goods and services and of the consequent chance of leading a flourishing life. People at the bottom of the (socio-economic) range ... have higher mortality rates than those in the middle of the socio-economic range" (2008, p.1).

According to the 2004 CCHS, children and adolescents in middle-income households were more likely to be overweight or obese than those in high-income households. For adults, lower socio-economic status tends to be associated with obesity. When level of education was examined, young people in households where no members had more than a high school diploma were more likely to be overweight/obese than those where the highest level of education was post-secondary graduation (Guillaume and Lissau, 2002; Hill and Lissau, 2002; Willms et al., 2003).

Oliver and Hayes (2008) conducted a longitudinal study using five cycles of data from the Canadian National Longitudinal Survey of Children and Youth on the relationship between neighbourhood and Body Mass Index (BMI). (BMI is a measure of obesity and overweight based on a person's weight and height. Increases in BMI mean increases in overweight or obesity.) Using census data to estimate the prevalence of low-income in each neighbourhood studied, they found that living in the poorest neighbourhood was associated with higher BMI compared to living in a middle-income neighbourhood. That is, children and adolescents living in lower-income neighbourhoods in Canada are more likely to be overweight and obese compared to children in middle-income neighbourhoods. This study provides direct Canadian evidence on the links between income and obesity in children and adolescents.

The impact of food security on health, particularly in low-income households, is an issue that has emerged as an area of concern in BC (Provincial Health Officer's Annual Report, 2005). It is apparent from recent research reviewed by the BC Legislature's Select Standing Committee on Health (2006) that children living in households with limited financial resources are more likely to suffer from a myriad of health problems and lower education outcomes. In a more direct recognition of the link between food security, income and health, preliminary studies indicate that children living in lower-income families are more likely to be overweight or obese.

Conclusions

Well-designed and representative surveys conducted in Canada indicate clear linkages between food security, income and health. The recent WHO report of the Commission on Social Determinants of Health (2008) (and two major reports conducted in BC by the Provincial Health Officer and the BC Legislative Assembly, Select Standing Committee on Health) underscore these linkages. At present about 10 percent of the Canadian population is food insecure, with those earning lower than average incomes being the most food insecure. The three groups most "at risk" for food insecurity include; families headed by single females, aboriginal peoples and marginally housed and homeless people. The food insecure tend to be more overweight and obese and have worse health status than those who are food secure.

As BC faces a growing epidemic of diet-related chronic diseases (such as hypertension and diabetes) it is essential to understand the relationship between food security and health. It is also important to note that the rates of many of these illnesses are much higher in the lower-income groups. Strategies to improve

food security of these populations – addressing both physical and economic access to nutritious food are essential to improving their overall food security. Programs and policies that improve food security are upstream interventions that have the potential for improving the health of BC's population and reducing the costs and burden associated with chronic diseases.

References

BC Legislature, Select Standing Committee on Health, 2006. A Strategy for Combating Childhood Obesity and Physical Inactivity in British Columbia, Legislative Assembly of British Columbia ISBN 0-7726-5651-7, Victoria.

Bocskei, E., and Ostry. A Survey of Charitable Feeding Programs for Poor and Homeless People in Victoria, BC. Canadian Journal of Dietetics, In Press.

Che, J., and Chen, J. (2001). Food insecurity in Canadian households. *Health Reports*, 12(4), 11-22.

Conference Board of Canada. (2009). How Canada Performs: A Report Card on Canada, Ottawa.

Coveney, J., and O'Dwyer, L.A. (2009). Effects of mobility and location on food access. *Health & Place*, 15(1), 45-55.

Dietitians of Canada. (2009) The Cost of Eating in BC 2009. Low–income British Columbians can't afford healthy food. Dietitians of Canada, BC Region and the Community Nutritionists Council of BC. http://www.dietitians.ca/pdf/CostofEating2009_revJan10.pdf

Dietitians of Canada. (2007) The Cost of Eating in BC 2007: The bite nutritious food takes from the income pie, Dietitians of Canada, BC Region and the Community Nutritionists Council of BC. http://www.dietitians.ca/resources/resourcesearch.asp?fn=view&contentid=1944

Eikenberry, N. and Smith, C. (2005). Attitudes, beliefs, and prevalence of dumpster diving as a means to obtain food by Midwestern, low-income, urban dwellers. *Agriculture and Human Values*, 22(2), 187-202.

First Call, Press Release, 2009. Available: http://www.firstcallbc.org/pdfs/CurrentIssues/presspercent20releasepercent20-percent20povertypercent20stats.pdf

Glanville, N.T., and McIntyre, L. (2006). Diet quality of Atlantic families headed by single mothers. Canadian Journal of Dietetic Practice & Research, 67(1), 28-35.

Guillaume, M., Lissau, I. Epidemiology. In: Burniat, W., Cole, T., Lissau, I., et al, eds. *Childhood and Adolescent Obesity: Causes and Consequences, Prevention and Management.* Cambridge: Cambridge University Press, 2002: 28-49.

Hagan, J. and McCarthy, B. (1997). Mean Streets: Y*outh Crime and Homelessness.* Cambridge, UK: Cambridge University Press.

Hamelin, A.M., Beaudry, M. and Habicht, J-P. (2002). Characterization of household food insecurity in Quebec: food and feelings. Social Science & Medicine, 54(1), 119-132.

Hamelin, A.M., Mercier, C. and Bedard, A. (2007). The food environment of street youth. *Journal of Hunger and Environmental Nutrition*, 1(3), 69-98.

Health Canada. (2007). *Canadian Community Health Survey, Cycle 2.2, Nutrition (2004) - Income-Related Household Food Security in Canada.* 4696. 2007. Ottawa: Office of Nutrition Policy and Promotion, Health Products and Food Branch, Health Canada.

Hickey, C. and Downey, D. (2003). *Hungry for Change: Social exclusion, food poverty and homelessness in Dublin*. Dublin: Focus Ireland.

Hill, A.J, and Lissau, I. Psychosocial factors. In: Burniat, W., Cole, T., Lissau, I., et al, eds. *Childhood and Adolescent Obesity: Causes and Consequences, Prevention and Management.* Cambridge: Cambridge University Press, 2002: 109-27.

Holben, D.H., McClincy, M.C., Holcomb, J.P., Dean, K.L. and Walker, C.E. (2004). Food security status of households in Appalachian Ohio with children in Headstart. *Journal of the American Dietetic Association*, 104(2), 238-241.

Khandor, E. and Mason, K. (2007). *The Street Health Report 2007*. Toronto: Street Health.

Kirkpatrick, S.I., and Tarasuk, V. (2007). Adequacy of food spending is related to housing expenditures among lower-income Canadian households. *Public Health Nutrition*, 10(12), 1464-1473.

Kirkpatrick, S.I., and Tarasuk V. (2008a) Food insecurity is associated with nutrient inadequacies among Canadian adults and adolescents. *Journal of Nutrition*, 138(3), 604-612.

Kirkpatrick, S.I., and Tarasuk, V. (2008b). Food insecurity in Canada - Considerations for monitoring. *Canadian Journal of Public Health-Revue Canadienne De Sante Publique*, 99(4), 324-327.

Larson, N.I., Story, M.T. and Nelson, M.C. (2009). Neighborhood environments disparities in access to healthy foods in the US. *American Journal of Preventive Medicine*, 36(1), 74-81.

Lawn, J. and Harvey, D. (2003). *Nutrition and food security in Kugaaruk, Nunavut.* R2-265/2003E. Ottawa: Minister of Indian Affairs and Northern Development.

Lawn, J. and Harvey, D. (2004). *Nutrition and food security in Fort Severn, Ontario*. R2-350/2004E. Ottawa: Minister of Indian Affairs and Northern Development.

Lawn, J. and Harvey, D. (2004a). N*utrition and food security in Kangiqsujuaq, Nunavik*. R2-341/2004E. Ottawa: Minister of Indian Affairs and Northern Development.

Ledrou I, Gervais J. (2005). *Food insecurity. Health Reports*, 16(3), 47-50

Li, A., Dachner, N., Tarasuk, V. (2009). Food intake patterns of homeless youth in Toronto. *Canadian Journal of Public Health*, 100(1), 36-40.

McIntyre, L. (2003). Food security: more than a determinant of health. *Policy Options*, 24(3), 46-51

McIntyre, L., Connor, S.K., and Warren, J. (2000). Child hunger in Canada: Results of the 1994 National Longitudinal Survey of Children and Youth. *Canadian Medical Association Journal*, 163(8), 961-965.

McIntyre, L., Glanville, N.T., Raine, K.D., Dayle, J.B., Anderson, B., and Battaglia, N. (2003). Do low-income lone mothers compromise their nutrition to feed their children? *Canadian Medical Association Journal*, 168(6), 686-691.

Moore, L.V., Diez Roux, A.V., Nettleton, J.A. and Jacobs, Jr., D.R. (2008). Associations of the local food environment with diet quality – A comparison of assessments based on surveys and geographic information systems. *American Journal of Epidemiology*, 167(8), 917-924.

Oliver L.N., and M. Hayes. (2008) Effects of neighbourhood income on reported body mass index: an eight-year longitudinal study of Canadian children, *BMC Public Health*, 8(16), http://www.biomedcentral.com/1471-2458/8/16

Ostry A. (2006a) Nutrition Policy in Canada, 1870-1939, *Vancouver: University of British Columbia Press*.

Papas, M.A., Alberg, A.J., Ewing, R., Helzlsouer, K.J., Gary, T.L. and Klassen, A.C. (2007). The built environment and obesity. *Epidemiologic Reviews*, 29(1), 129-143.

Provincial Health Officer's Annual Report, 2005. Victoria, BC. www.health.gov.bc.ca/pho/pdf/phoannual2005.pdf, (2005)

Radimer, K.L., Olson, C.M., Greene, J.C., Campbell, C.C. and Habicht, J-P. (1992). Understanding hunger and developing indicators to assess it in women and children. *Journal of Nutrition Education*, 24(1, Suppl.), 36S-44S.

Sharkey, J.R. (2009). Measuring potential access to food stores and food-service places in rural areas in the US. *American Journal of Preventive Medicine*, 36(4), S151-S155.

Sharkey, J.R. and Horel, S. (2008). Neighborhood socio-economic deprivation and minority composition are associated with better potential spatial access to the ground-truthed food environment in a large rural area. *Journal of Nutrition*, 138(3), 620-627 Shields M. (2005). Measured Obesity Overweight Canadian children and Adolescents, Nutrition: Findings from the Canadian Community Health Survey, Statistics Canada, Ottawa, Social Planning and Research Council of British Columbia. (2008). Child Poverty Report Card, Available: http://www.campaign2000.ca/rc/rc08/BC_ReportCard08-colour.pdf.

Story, M., Kaphingst, K.M., Robinson-O'Brien, R. and Glanz, K. (2008). Creating healthy food and eating environments: Policy and environmental approaches. *Annual Review of Public Health*, 29, 253-272.

Tarasuk, V.S. (2001b). Household food insecurity with hunger is associated with women's food intakes, health, and household circumstances. *Journal of Nutrition*, 131(10), 2670-2676.

Tarasuk, V., McIntyre, L. and Li, J. (2007). Low-income women's dietary intakes are sensitive to the depletion of household resources in one month. *Journal of Nutrition*. 137(8), 1980-1987.

Tarasuk, V, Dachner, N., Poland B, and Gaetz, S. (2009). Food deprivation is integral to the 'hand to mouth' existence of homeless youth in Toronto. *Public Health Nutrition* [On-line]. Available: doi:10.1017/S1368980008004291.

Vancouver Coastal Health Authority. 2008. Food security and housing: *Preliminary rationale and strategies for the subsidized housing sector, Vancouver.*

Vozoris, N., Davis, B. and Tarasuk, V. (2002). The affordability of a nutritious diet for households on welfare in Toronto. *Canadian Journal of Public Health-Revue Canadienne De Sante Publique*, 93(1), 36-40.

Vozoris, N.T. and Tarasuk, V. S. (2003). Household food insufficiency is associated with poorer health. *Journal of Nutrition*, 133(1), 120-126.

Wang, M.C., Cubbin, C., Ahn, D. and Winkleby, M. A. (2008). Changes in neighbourhood food store environment, food behaviour and body mass index, 1981-1990. *Public Health Nutrition*, 11(9), 963-70.

Willms J.D., Tremblay M.S., and Katzmarzyk, P.T. Geographic and demographic variation in the prevalence of overweight Canadian children. *Obesity Research 2003*; 11(5): 668-73.

World Health Organization, Commission on Social Determinants of Health (2008). Closing the Gap in a Generation: health equity through action on the social determinants of health. http://www.who.int/social_determinants/thecommission/finalreport/en/index.html

Chapter Two:
Climate Change and Food Security in British Columbia: Primary and Secondary Impacts

Climate change presents an emerging challenge to food security both in BC and throughout the world. Changes in climate that may occur in the near and medium term are outlined in this chapter and potential secondary effects that may be important to agricultural productivity and food security (Pacific Institute for Climate Solutions, 2009) are discussed. Chapters Three through Five then look at specific issues, such as food imports, agricultural production in BC and food miles, and how they could affect the long-term food security in BC.

Two types of evidence are examined in this chapter: (1) the limited evidence predicting the intensity and pace of climate change in BC and (2) the evidence linking increased greenhouse gasses, temperature and changes in precipitation to agricultural productivity. There are limitations to this approach. Since accurate climate change data at the regional and sub-regional level in BC are not yet available, only rudimentary predictions may be made. The pace of warming and precipitation change across the different and complex topographical and climactic regions of BC is not yet well understood. In addition, as the impacts of climate change on food production has been modeled mainly on major staple crops, the effect of climate change on many other crops important to BC are simply unknown. Finally, as this food production research is only available at national or supra-national levels, we can only roughly extrapolate the results of these investigations to smaller geographic regions within BC.

While limited, this approach is valid as general conclusions about policy direction may still be drawn. There are indications that climate change is unfolding swiftly. In the absence of accurate predictive data, the evidence presented is the most current research that can be placed in the hands of policy makers in order that they may make the best possible decisions.

Primary Impacts of Climate Change in BC

If global climate change is not reversed, the impacts on agricultural productivity and human food security will be significant by the end of the 21st century. Simply put, the earth will become less able to grow enough food to feed humans (Battisti and Naylor, 2009). Even if we move rapidly to reduce greenhouse gasses over the next quarter to half century, policy makers will need information and advice on how to adapt and forestall adverse impacts on food security. For this to happen, we must have a clearer understanding of the likely

short and medium term impacts of climate change in BC and some assessment of how these impacts may affect agricultural productivity and food security.

In recent decades BC's climate has warmed, with changes in temperature and precipitation in southern BC exceeding global average changes (BC Ministry of Environment, 2006; Whitfield et al., 2002a; Zhang et al., 2000). These trends are likely to continue, even if greenhouse gas emissions are reduced significantly. In addition to warming, precipitation patterns will shift, making most regions of the province wetter during the winter and spring and drier during summer (Walker and Sydneysmith, 2007).

Temperature increases have already resulted in reduced snowpack (Stewart et al., 2004) and rapidly melting alpine glaciers (Moore et al., 2007) and this will accelerate as temperatures rise (Mote and Hamlet, 2001). In turn, reduced snowpack and glaciations have already changed stream flow volumes and timing. Spring snowmelt now occurs much earlier in many BC rivers (Zhang et al., 2001), a trend that can be expected to increase in the short and medium term.

With melting glaciers, sea levels are expected to rise. While accurate predictions are difficult to make due to the countervailing rise in coastal land height from tectonic plate action (Walker and Sydneysmith, 2007), any rise in sea level poses challenges, particularly to southwestern BC.

More extreme weather events have been documented worldwide and most projections suggest these will increase (Easterling et al., 2000). As a result of increased frequency and severity of extreme weather events, costly droughts and floods have occurred in BC. In the period 1999 to 2002 for example, climate-related natural disasters cost BC an average of 10 million dollars per year. From 2003 to 2005 average yearly costs of these types of disasters rose to 86 million dollars per year, substantiating a dramatic recent increase in the impact of extreme weather events (Whyte, 2006). While part of this escalation may be attributed to increased re-construction and insurance costs, most is a direct result of frequent and severe weather events.

Secondary Impacts of Climate Change in Relation to Food Security

In the short to medium term, research indicates a potential expansion of agricultural productivity for many staple crops in temperate regions such as BC (Easterling et al. 2007). Various models also suggest that as northern regions warm, such as the Peace River Valley, the range and types of crops grown could actually increase (Zebarth et al., 1997). However, in the long term, if global warming continues unabated this window will close and quickly reverse. In the meantime, worsening climactic conditions in BC are likely to adversely impact food security through:

A. physical degradation of land and water used in agriculture;

B. biological changes such as increases in plant and animal pathogens in staple crops;

C. destabilization of communities through degradation of local agriculture, lost jobs and incomes, directly reducing the ability to purchase food.

A. Physical degradation of land and water used in agriculture

Along the coast and coastal valleys a rise in sea level may cause groundwater and land quality degradation through salination (Rivera et al., 2004). Also along the coasts, high winter stream flow and increased groundwater levels, coupled with increased runoff, may lead to greater erosion and contamination of agricultural land and water (Moore et al., 2007; Whitfield et al., 2002b).

Flooding, increased winter runoff and sedimentation of streams can adversely affect salmon breeding habitat and reduce the already stressed BC wild salmon fishery (Lytle and Poff, 2004; Montgomery et al., 1996). (It must be noted that there are many other factors that impact fish habitats and the fish industry in BC – issues which are too numerous and complex to be covered here in this paper.) And, given that floods tend to occur more often in agriculturally productive flood plains, including the Peace and Fraser River Valleys, increased flooding may negatively affect crop growth. This is particularly true if contaminant levels increase (Kenerley et al., 1984; Rosenzweig et al., 2002).

While coastal areas may experience more hazards related to increased water, earlier spring melt coupled with shifts to more precipitation in winter and less in summer will reduce summer groundwater recharge rates. Conversely, in the Okanagan and other dry regions of the province, more frequent and prolonged droughts, particularly during peak summer demand periods, can be expected (Walker and Sydneysmith, 2007).

The secondary impacts on agriculture due to increased fire and flood could be considerable in those regions of the province affected by forest kill due to mountain pine beetle (MPB) infestation. Dead standing trees present a fire risk and exacerbate rapid water run-off patterns in the spring. It is likely that increased fire and flood will occur, particularly in the zones of the province affected by MPB (Patriquin et al., 2005). In fact, in Western North America, forest fires are now more frequent and severe (Westerling et al., 2006) and are projected to become more frequent and more severe in Western Canada (Flannigan et al., 2005; Gillet et al., 2004). Degradation of water and land used for agriculture in these areas is possible.

Air pollution and increased ozone exposure occurring with temperature increases may adversely impact crop production, particularly near urban regions in BC (Katsouyanni, 1993). And, with more severe and frequent forest fires, air pollution/temperature interactions could increase particulate exposure from wood smoke and further compromise crop yields (Simkhovich et al., 2008).

Finally, as temperature increases, developed urban areas become prone to the “urban heat island effect.” Very high temperatures in concrete urban cores may reduce the option of relying more on urban gardening (Aniello, 1995).

B. Biological changes that may impact food security

As well as the physical changes outlined above, biological changes arise when temperatures and precipitation increase. With the increased precipitation and flooding caused by climate change, water-borne diseases affecting animals and plants may increase (Mullens, 1996).

Climate change also impacts vector-borne disease by increasing the range and abundance of animal or insect reservoirs and the importation of new vectors. Temperature increases alter living conditions for both

animal and plant vectors (Patz et al., 1996). The combination of higher average rainfall and temperatures, and the earlier onset of spring predicted for BC, could result in prolonged transmission cycles for vectors of human, plant and animal disease (Sutherst, 2004).

New fungal pathogens that originate in warmer and wetter climates may find the local soil ecology and climate more welcoming with climate change. The tropical fungus Cryptococcus gatti, for example, first appeared in 1999 on the southeast coast of Vancouver Island (Kidd et al., 2004). This fungus, which appears to be spreading from Vancouver Island to the Lower Mainland, has caused over 100 cases of human illness and many more cases of animal illness (Greer et al., 2008). Rises in summer temperatures will likely see growth in the prevalence of food–borne gastroenteritis, particularly illnesses related to Campylobacter and Salmonella (Bowman et al., 2003; Gubler et al., 2001).

C. The impact of community dislocation on food security

Rural and remote areas in central and northern BC already face a severe climate-change related disaster: infestation of the mountain pine beetle (Patriquin et al., 2005). Rural resource-dependent communities will see further depletion of the main resource in the area, leading to socio-economic decline. Vulnerable communities and communities with vulnerable populations will be particularly affected (Hayter, 2000; Hayter and Barnes, 1992). Many of these communities face the double threat of both increased fires and floods. In these communities the dislocation caused by climate change is likely to worsen the already adverse food security situation.

Aboriginal communities, particularly those in coastal regions, in MPB affected zones and those already economically and environmentally challenged, are at risk for further adverse impacts on food security. This may be particularly true for communities highly dependent on “wild foods” such as salmon that are directly threatened by climate change.

Conclusion

Establishing the magnitude of impact that climate change will have on food security in BC is a challenge. It is likely that the frequency and severity of extreme weather events will increase. Warmer, wetter winters and drier, hotter summers bring the prospect of frequent fires, floods, rising sea levels, loss of community income, reduced agricultural productivity and more diseases affecting both plants and animals. While the coasts may experience more hazards related to increased water inundation, frequent and prolonged droughts will occur in dry regions of the province.

Even with reduced greenhouse gas emissions the trend is likely to continue and the implications are serious. Worsening climactic conditions in BC are likely to impact food security through physical degradation of land and water, biological changes (especially the introduction of new animal and plant disease vectors) and community destabilization. Perhaps the most important way in which climate change is already affecting communities is through social, economic and agricultural dislocation of rural and remote communities in central and northern BC. In the future, climate change may affect the food security of BC communities due to its impact in places outside our borders. This is examined in the next chapter.

References

Aniello, C., Morgan, K., Busbey, A. and Newland, L. Mapping Micro-Urban Heat Islands Using Lansat TM and a GIS. Computer & Geosciences, 21: 965-969, 1995.

Barnes T.J., Hayter R. and Hay E. Stormy Weather: Cyclones, Harold Innis, and Port Alberni, BC. Environment and Planning C, 33: 2127-2147, 2001.

Battitsti D. and Naylor R. Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat. *Science*, 9 (323): 240-44, 2009.

BC Ministry of Environment. 2006. *British Columbia's Coastal Environment.* BC Ministry of Environment.

Bowman, C., Flint, J. and Pollari, F. Canadian Integrated Surveillance Report: Salmonella, Campylobacter, pathogenic E. coli and Shigella, from 1996 to 1999. *Canadian Community Disease Reports*, 3: 29 (Suppl 1): i-vi, 1-32, 2003.

Easterling, D.R., Meehl, G.A., Parmesan, C., Changnon, S., Karl T.R. and Mearns, L.O. Climate Extremes: Observations, Modeling and Impacts. *Science,* 289(5487): 2068-2074, 2000.

Easterling, W.E., Aggarwal, P.K., Batima, P., Brander, K.M., Erda, L., Howden, S.M., Kirilenko, A., Morton, J., Soussana, J.F, Schmidhuber, J. and Tubiello, F.N. Food, fibre and forest products. In *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, (eds), Cambridge University Press, Cambridge, UK, 273-313, 2007.

Flannigan, M.D., Logan, K.A., Amiro, B.D., Skinner, W.R. and Stocks, B.J. Future Area Burned in Canada in Canada. *Climatic Change*, 72: 1-16, 2005.

Gillet, N.P., Weaver, A.J., Zweirs, F.W. and Flannigan, M.D. Detecting the Effect of Climate Change on Canadian Forest Fires. *Geophysical Research Letters*, 31(L): 18211, doi:10.1029/2004GL020876, 2004

Greer, A., Ng, V. and Fisman, D. Climate Change and Infectious Disease in North America: The Road Ahead. *Canadian Medical Association Journal,* 178(6): 715-722, 2008.

Gubler, D.J., Reiter, P., Ebi, K.L., Yap, W., Nasci, R. and Patz, J.A. Climate Variability and Change in the United States: Potential Impacts on Vector- and Rodent-borne Diseases. *Environmental Health Perspectives* 109 (Suppl. 2): 223-233, 2001.

Hayter, R. *Flexible Crossroads: The Restructuring of British Columbia's Forest Economy.* Vancouver: University of British Columbia Press, 2000.

Hayter, R. and Barnes, T.J. Labour Market Segmentation, Flexibility, and Recession: a British Columbian Case Study. *Environment and Planning C: Government and Policy* 10(3): 333-353, 1992.

Katsouyanni, K., Pantazopoulou, A., Touloumi, G., Tselepidaki, I., Moustris, K., Asimakopoulos, D., Poulopoulou, G. and Trichopoulos, D. Evidence for Interaction between Air Pollution and High Temperature in the Causation of Excess Mortality. *International Journal of Biometeorology* 48(4): 235-242, 1993.

Kenerley, C., Papke, K. and Bruck, R. Effect Of Flooding On Development of Phytophthora Root-Rot in Fraser Fir Seedlings. *Phytopathology*, 74: 401-404, 1984

Kidd, S.E., Hagen, F., Tscharke, R.L., Huynh, M., Bartlett, K.H., Fyfe, M., MacDougall, L., Boekhout, T., Kwon Chung, K.J. and Meyer, W. A Rare Genotype of Cryptococcus Gatti Caused by Cryptococcosis Outbreak on Vancouver Island. In *Microbiology, Proceedings of the National Academy of Sciences of the USA* 101(49): 17258-17263, 2004.

Lytle, D.A. and Poff, N.L. Adaptation to Natural Flow Regimes. *Trends In Ecology & Evolution* 19: 94-100, 2004

Montgomery, D.R., Buffington, J.M. and Peterson, N.P. Stream-bed Scour, Egg Burial Depths, And The Influence Of Salmonid Spawning On Bed Surface Mobility And Embryo Survival. *Canadian Journal of Fisheries and Aquatic Sciences* 53: 1061-1070, 1996.

Moore, R.D., Allen, D.M. and Stahl, K. *Climate Change and Low Flows: Influences of Groundwater and Glaciers.* Final Report for Climate Change Action Fund Project A875, 2007.

Mote, P.W. and Hamlet, A.F. Anthropogenic Climate Change and Snow in the Pacific Northwest. In P*roceedings of the 69th Annual Meeting of the Western Snow Conference.* April 16-19, 2001. Sun Valley, Idaho, p.51-52.

Mullens, A. 1996. *Canadian Medical Association Journal,* 15411: 1721-1724, 1996.

Pacific Institute for Climate Solutions. *White Papers.* 2009. http://www.pics.uvic.ca/research.php

Patriquin, M., Heckbert, S., Nickerson, C., Spence, M. and White, W. *Regional Economic Implications of the Mountain Pine Beetle Infestation in the Northern Interior of British Columbia*. Mountain Pine Beetle Initiative Working Paper 2005-3. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, 2005.

Patz, J., Epsttein, P., Thomas, A., Burke, A. and Balbus, J. Global Climate Change and Emerging Infectious Diseases. *Journal of the American Medical Association,* 275: 217-223, 1996.

Rivera, A., Allen, D.M. and Maathuis H. Climate Variability and Change- Groundwater Resources. In: *Threats to Water Availability in Canada*, pp. 77-83, Environment Canada, National Water Research Institute, 2004.

Rosenzweig, C., Tubiello, F.N. and Goldberg, R. Increased Crop Damage In The US From Excess Precipitation Under Climate Change. *Global Environmental Change-Human And Policy Dimensions* 12: 197-202, 2002.

Simkhovich, B.Z. and Kleinman, M. Air Pollution and Cardiovascular Injury Epidemiology, Toxicology, and Mechanisms. *Journal of the American College of Cardiology*, 52(9): 719-726, 2008.

Stewart, I.T., Cayan, D.R. and Dettinger, M.D. Changes in Snowmelt Runoff Timing in Western North American Under a "Business as Usual" Climate Change Scenario. *Climatic Change*, 62: 217-232, 2004.

Sutherst, R.W. Global Change and Human Vulnerability to Vector-borne Diseases. *Clinical Microbiological Revue*, 17(1): 136-173, 2004.

Walker, I.J. and Sydneysmith, R. British Columbia. In *From Impacts to Adaptation: Canada in a Changing Climate*. Lemmen, D.S., Warren, F.J., Lacroix, J. and Bush, E, (eds), pp.329-386, Government of Canada, Ottawa, 2007.

Westerling, A.L., Hidalgo, H.G., Cayan, D.R. and Swetnam, T.W. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. *Science*, 313(5789): 940-943, 2006.

Whitfield, P.H., Bodtker, K. and Cannon A.J. Recent Variations in Seasonality of Temperature and Precipitation in Canada, 1976-1995. *International Journal of Climatology*, 22: 1617-1644, 2002a.

Whitfield, P.H., Reynolds, C.J. and Cannon, A.J. Modelling Streamflows in Present and Future Climates: Examples from Georgia Basin, British Columbia. *Canadian Water Resources Journal*, 27(4): 427-456, 2002b.

Whyte, J. *Extreme Weather Impacts on Provincial Emergency Programme (PEP) and Public Safety: Canadian Water Resources Association Conference*, Victoria, BC, 2006.

Wilkinson, P. Climate Change & Health: the Case for Sustainable Development. Medicine, *Conflict and Survival,* 24(1): 26-35, 2008.

Zebarth, B., Caprio, J., Broersma, K., Mills, P. and Smith S. *Effect of Climate Change on Agriculture in British Columbia and the Yukon. Volume 1. Canada Country Study: Climate Impacts and Adaptation.* Taylor, E. and Taylor, B. (eds). Environment Canada and BC Ministry of Environment, Lands, and Parks, 1997.

Zhang, X., Vincent, L.A., Hogg, W.D. and Nitsoo, A. Temperature and Precipitation Trends in Canada during the 20th Century. *Atmosphere-Ocean*, 38(3): 395-429, 2000.

Zhang, X., Harvey, D.K., Hogg, W.D. and Yuzyk, T.D. Trends in Canadian Stream Flow. *Water Resources Research*, 37(4): 987-998, 2001.

Chapter Three: Climate Change, Food Imports and Food Security in British Columbia

Approximately 45 percent of BC's food is imported from other regions of Canada or from other nations. As climates around the world become colder, hotter, wetter or drier, food production becomes unpredictable and food security may be compromised. To understand the potential impact of climate change on food security of British Columbians, it is necessary to identify the foods we import, the most common points of origin of these foods and how agricultural productivity in these regions might be affected.

The first section of this chapter describes food production in BC as well as food import and export patterns. The second and third sections identify the foods primarily imported from other countries and the regions these foods come from, using Industry Canada trade data for the period from 1998 to 2007. Given that BC is highly reliant on food imports from the United States, California in particular, the impact of climate change on agricultural productivity in this region is examined. These results and the best possible predictions for food security in BC are discussed in the final section of this chapter.

Food Imports, Exports and Food Production in BC

As shown in Table 1, three percent of BC's food was imported in 1946. This proportion rose to a peak of 60 percent in the 1970s. Since the 1990s food imports have remained in the 40 to 45 percent range. At present we are reliant on many imported foods, although the degree of reliance varies for different categories of food.

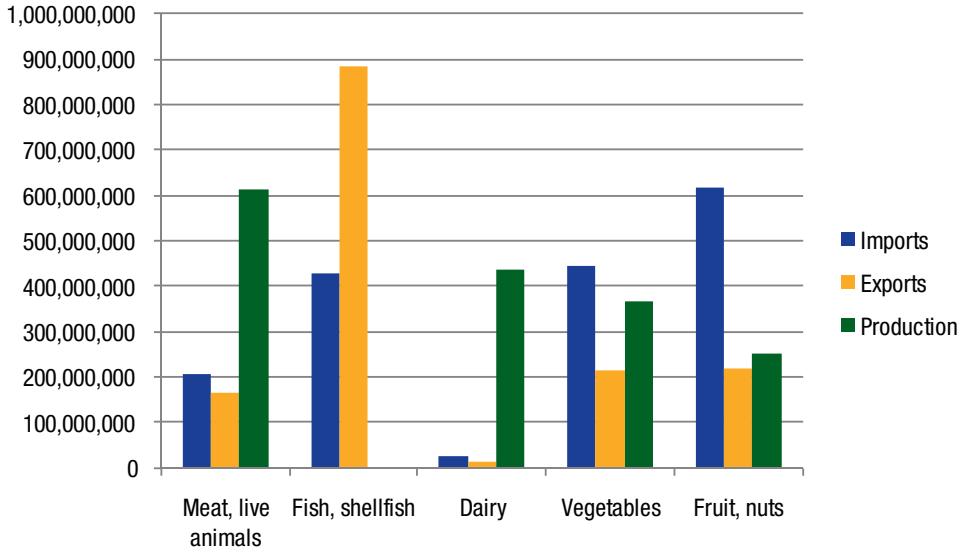
Table 1: Proportion of Food Imported Into BC in 1946, 1955, 1970s, 1990s and 2008.

Year	Proportion imported
1946	3%
1955	29%
1970s	60%
1990s	40%
2008	45%

(Furuseth and Pierce, 1982; Statistics Canada, 2008)

The 2007 import and export data from Industry Canada and production data from Statistics Canada can be used to determine the relative proportion of reliance on imports compared to within-province production for the major food categories of fruit, vegetables, fish, dairy products and meat (Figure 1).[2] Overall, BC produced about $3.0 billion, imported about $2.1 billion and exported about $1.6 billion worth of food in 2007. The largest sub-component, by value, of the agriculture production sector in BC is fish and livestock. In 2007 about $1.3 billion of fish and $600 million of livestock and meat products were produced in BC.

Figure 1: Approximate Value in Canadian Dollars of Foods Imported Into, Exported From and Produced In British Columbia in 2007



Imports and exports data:
Source: Industry Canada. 2007. "Trade Data Online (TDO) By Product.
http://www.ic.gc.ca/sc_mrkti/tdst/tdo/tdo.php. Canadian $.

Production data:
Statistics Canada CANSIM Table 002-0001. Farm Cash Receipts, 2007.
http://estat.statcan.gc.ca/cgi-win/cnsmcgi.exe?Lang=E&EST-Fi=EStat/English/CII_1-eng.htm

A few general observations arise from these data. Dairy is the most "local" food industry in the province. That is, most dairy products are produced in BC and import and export markets are small. A somewhat similar pattern exists for live animals and meat. In contrast, fishing has dynamic imports, exports and within BC production. Vegetables, fruits and nuts lie between these extremes.

Based on these data, at a very basic level, climate change within BC is most likely to impact food security in terms of access to dairy, fish and meat products. This will be discussed in more detail in the next chapter.

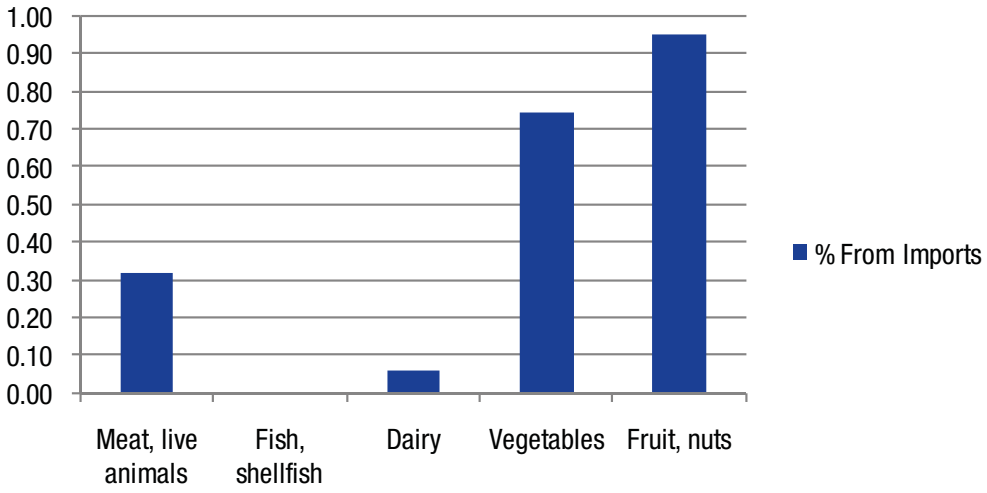
Data are available on the value of foods produced in BC, imported from other nations, foods consumed in BC and exported to other nations. However, these data do not provide a complete picture of food produced, imported to and exported from BC as data on existing stocks of foods held over from previous years, wastage and inter-provincial imports and exports are difficult to obtain, therefore are not included. Notwithstanding these limitations, we can roughly determine the proportion of consumption accounted for

2 Industry Canada has data on the Canadian dollar value of foods imported into BC and exported from BC and, Statistics Canada has data on the value of foods produced in BC. Because Industry Canada and Statistics Canada classify foods in different ways, it is difficult to accurately compare the volume or value of imported and BC produced foods to determine the relative import dependence for different types of foods. By aggregating Statistics Canada food categories it is possible to arrive at a rough estimation of value of foods, by basic food category, that are both imported and produced in BC.

by food imported across international borders. In order to obtain a more complete picture, it is necessary to identify the imported foods upon which BC is most reliant, to determine where they come from and examine the potential impact of climate change on food production in these areas.

Figure 2 demonstrates we are most reliant on foreign sources for fruits and nuts (95 percent), followed by vegetables (75 percent) and fish (65 percent).

Figure 2: Estimate of Consumption of Major Imported Food Categories in BC (by Value in Canadian Dollars), 2007



Source: Industry Canada. 2007. "Trade Data Online (TDO) By Product. http://www.ic.gc.ca/sc_mrkti/tdst/tdo/tdo.php. Canadian $.

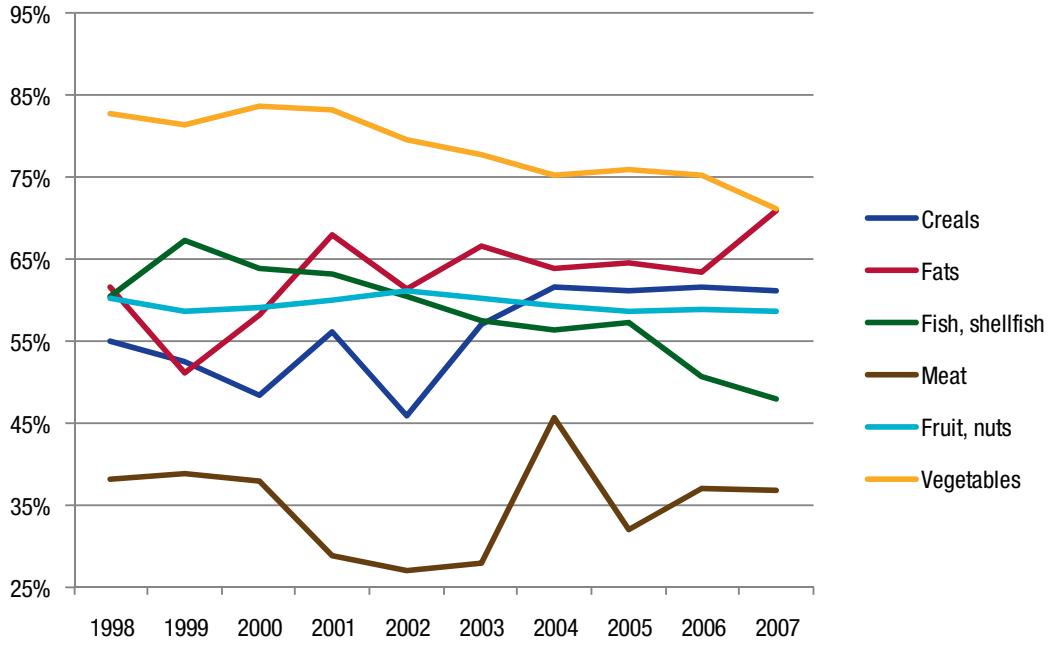
Nutritionists are increasingly encouraging the consumption of more vegetables, fruits, nuts and fish. With a secure food source the net effect would be higher consumption and increased demand for these types of foods. Given current import, export and production patterns, nutritionists' recommendations could stimulate further imports of these products.

From Where Does BC Import Food?

BC imports food from other provinces including, for example, large quantities of processed beef from Alberta. However, the volume and type of food imported from all provinces remains largely unknown. This limits the ability to clearly predict how climate change might impact BC's food supply imported from other agricultural regions across Canada.

In 1998 and in 2007 approximately 60 percent of BC's food imports came from the United States. In 2007 approximately 70 percent of fats and vegetables, 60 percent of cereals, fruit, nuts, seafood and fish, 50 percent of shell fish and 40 percent of meat imported into BC came from the United States (Figure 3, Industry Canada, 2007). As shown in Figure 2, the proportion of major foods imported from the USA had changed somewhat by 2007, but the pattern of dependence on US sources has remained largely intact for the past decade.

Figure 3: Proportion of Imports from the USA Into BC By Major Food Categories, 1998 to 2007

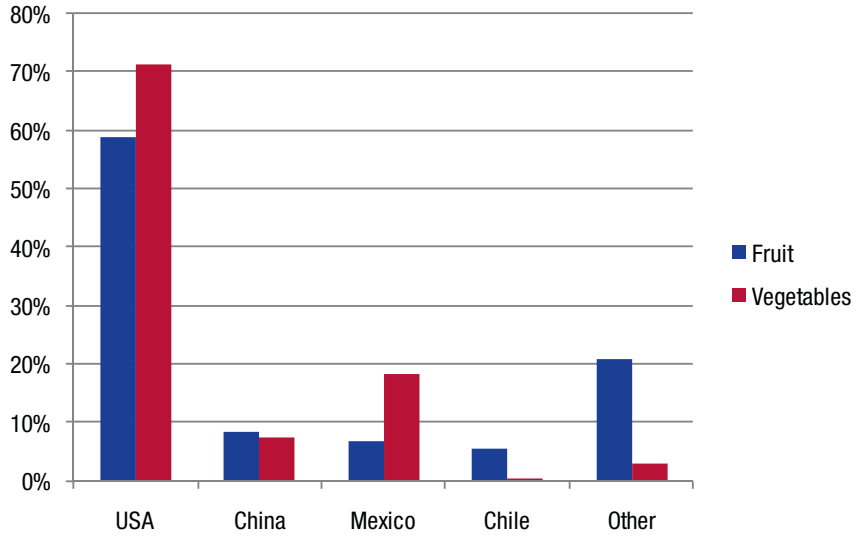


Source: Industry Canada. 2007. "Trade Data Online (TDO) By Product http://www.ic.gc.ca/sc_mrkti/tdst/tdo/tdo.php. Canadian $.

Other than the USA, Australia and New Zealand supply a significant proportion of meat to British Columbians. These nations supplied about 55 percent of meat imports in 2007, however, imports form a relatively small proportion of total meats consumed in BC. If supplies from these two nations were eliminated as a result of adverse climate events, the impact would be relatively small on overall food security in BC.

BC is more reliant on imports for fruits and vegetables than for meat. Figure 4 illustrates that 60 percent of BC's imported fruit comes from the United States, about 20 percent from China, Mexico and Chile, and the remaining 20 percent comes from about 30 other nations. Approximately 70 percent of imported vegetables come from the United States, about 20 percent from Mexico and just under 10 percent from China. Thus for fruits and vegetables the United States is most important, followed by Mexico and China.

Figure 4: Major Source Nations for Imports of Fruit and Vegetables - Proportion Imported Into BC



Source: Industry Canada. 2007. "Trade Data Online (TDO) By Product. http://www.ic.gc.ca/sc_mrkti/tdst/tdo/tdo.php. Canadian $.

These data indicate that the impact of climate change in the United States, and to a lesser extent in Mexico and China, will be important to BC food security. Given that California produces half of the fruits and vegetables produced in the USA (California Department of Food and Agriculture, 2006), the impact on climate change on agricultural regions in central California will be crucial to BC's future food security.

Impact of Climate Change on Agricultural Productivity in the United States

Studies of agricultural production in response to climate change in the United States (Adams, Hurd, Lenhart and Leary, 1998) have modeled complex interactions of temperature and precipitation changes including: increased climate variation, changes in pesticide use, environmental effects caused by agriculture (for example, erosion, agricultural runoff into waterways), changing global markets, societal responses and technological adaptation (National Assessment Synthesis Team, 2001; Reilly et al., 2003; Smith et al., 2005).

These national projections could be quite different in California because of their limited water resources and focus on specialty crops. Agriculture will be impacted by shifts in temperature and precipitation, their interactions and the seasonality of such effects. The incidence of extreme weather events may also increase (IPCC, 2001). A range of possible climate futures has been predicted for California (Hayhoe et al., 2004). These models forecast higher average increases in temperature relative to other regions of the USA. Although precipitation predictions are less certain, some models indicate significant decreases in rainfall – up to 30 percent in the Central Valley and the Pacific Coast (Hayhoe et al., 2004). This would significantly impact the major agricultural regions of the state. An increase in winter rainfall could lead to a doubling of the winter runoff by 2090, complicating the uncertainty associated with regional precipitation projections (National Assessment Synthesis Team, 2001).

Water supply is central to the success of California agriculture. In addition to changes in precipitation, water availability will be influenced by rising temperatures (and hence evaporation), and consequential increases

in water demand from other sectors. Increased temperatures will affect the amount of water collected and stored in the Sierra snowpack, which is predicted to be 30 to 70 percent lower by the end of the century due to an increase in rainfall versus snowfall and earlier melting of the snowpack (Hayhoe et al., 2004). This change will be most prominent in the southern Sierra Nevada where 80 percent of California's snowpack storage currently occurs.

The changing availability of water for agriculture in California may lead to heavy reliance on groundwater resources currently stretched beyond capacity in many agricultural areas (Department of Water Resources, 1998). Demand for water resources will be further exacerbated by an increase in the population of California in the coming century, which is projected to be 46 million people by 2030 and may reach 90 million by 2100 (U.S. Census Bureau, 2005).

The impacts of these anticipated climatic changes in California include diminished yields (Peng et al., 2005; Sato, Peet and Thomas, 2000; West, 2003; DeJong, 2005; Moya, Ziska, Namuco and Olszyk, 1998; Wheeler, Hadley, Morison and Ellis, 1993), reduced product quality (Southwick and Uyemoto, 1999) and shifts in growing regions suitable for specialty crops (Reilly and Graham, 2001). Increased temperatures may adversely affect yields of tomato (Sato et al., 2000), rice (Moya, Ziska, Namuco and Olszyk, 1998; Ziska, Namuco, Moya and Quilang, 1997), stone fruits (DeJong, 2005), grapes (Hayhoe et al., 2004) and milk (West, 2003), but allow for more crops of lettuce (Wheeler et al., 1993) and expansion of citrus production (Reilly and Graham, 2001), as well as heat and drought-tolerant trees, such as olives.

At this point California is suffering from its worst drought in decades, with predictions of more years of drought to come. The state is under water rationing restrictions and agricultural production and employment is declining. This does not bode well for the food security of British Columbians, notwithstanding any short-term ability to find alternative sources for imports.

Food Imports and Food Security in BC

Given that the bulk of our imports of vegetables, fruit and nuts come from the United States, the way in which climate change unfolds in that country will have a major impact on consumption patterns in BC. As climactic conditions worsen in the US, and in particular California, the pressure to reduce exports will grow. This, along with price increases due to decreased production, will reduce British Columbians' access to these foods. The most productive fruit-growing region in BC is the Okanagan, an area particularly vulnerable to climate change. The extent to which climate change related reductions in fruit imports from the USA can be balanced by increased production in conventional fruit growing areas in BC is unknown.

Reduced access to local and imported fruit may be the first aspects of climate related food insecurity to manifest itself in BC. This is key as nutritionists are recommending that British Columbians consume more fruit.

Most of the studies quoted in this chapter on the impacts of climate change on food security were conducted prior to 2005. Today there is concern that climate change projections to this point have been too rosy. While some modeling of worst-case climate change scenarios have been conducted in relation to the impacts on food security, these are fairly general and offer little scientific evidence on the food security/climate change situation presently facing BC (Lobell, 2008; Schmidhuber and Tubiello, 2007). Though the

data currently available are insufficient, raising more questions than answers, they do call for policy-makers to focus on how best to handle the impending threats to BC's food security.

Conclusion

Approximately 45 percent of food consumed in BC is imported from other regions of Canada, or from other nations. In order to appreciate how food security in BC may be affected by global climate change we need to understand BC food production, as well as our import/export patterns. Most dairy and meat products consumed by British Columbians are produced here at home and from this perspective local climatic changes are of primary concern. In contrast 60-70 percent of our fruits and vegetables come from the United States, making any variation in US agricultural productivity of particular interest. Changes in temperature or precipitation and incidences of extreme weather events have the potential to impact those agricultural regions around the world on which we depend. Highlighting the potential impact climate change could have on food security may help plan the strategies and actions to mitigate these adverse impacts.

The next chapter discusses local climatic changes and their impact on future food security in BC.

References

Adams, R.M., Hurd, B.H., Lenhart, S. and Leary, N. Effects of global climate change on agriculture: An interpretative review. *Climate Research*, 11: 19–30, 1998.

Butt, T.A., McCarl, B.A., Angerer, J., Dyke, P.T. and Stuth, J.W. The economic and food security implications of climate change in Mali. *Climatic Change*, 68: 355-378, 2005.

California Departments of Food and Agriculture. *California Agricultural Statistics*, 2006.

DeJong, T.M. Using physiological concepts to understand early spring temperature effects on fruit growth and anticipating fruit size problems at harvest. *Summerfruit Australia Quarterly*, 7: 10-13, 2005.

Department of Water Resources. 1998. *California Water Plan: Bulletin* 160-98 Ed D o P aL Assistance. California Department of Water Resources.

Easterling W. and Apps, M. Assessing the consequences of climate change for food and forest resources: A view from the IPCC. *Climatic Change*, 70: 165-189, 2005.

Furuseth, O. and Pierce, J. 1982. *Agricultural Land In An Urban Society.* Association of American Geographers, Washington, D.C.

Hayhoe, K., Cayan, D., Field, C.B., Frumhoff, P.C., Maurer, E.P., Miller, N.L., Moser, S.C., Schneider, S.H., Cahill, K.N., Cleland, E.E., Dale, L., Drapek, R., Hanemann, R.M., Kalkstein, L.S., Lenihan, J., Lunch, C.K., Neilson, R.P., Sheridan, S.C. and Verville, J.H. Emissions pathways, climate change, and impacts on California. *Proceedings of the National Academy of Sciences of the United States of America* 101, 12422-12427, 2004.

Industry Canada. 2009. Trade Data Online (formerly called Stategis). Available online at http://www.ic.gc.ca/eic/site/tdo-dcd.nsf/eng/Home

IPCC. 2001. IPCC *Third Assessment Report: Climate Change 2001*. Cambridge: University Press, Cambridge.

IPCC. 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds). Cambridge: Cambridge University Press.

Kimball, B.A., Morris, C.F., Pinter, P.J., Wall, G.W., Hunsaker, D.J., Adamsen, F.J., LaMorte, R.L., Leavitt, S.W., Thompson, T.L., Matthias, A.D. and Brooks, T.J. Elevated CO2, drought and soil nitrogen effects on wheat grain quality. *New Phytologist*, 150: 295-303, 2001.

Lobell, D.B., Burke, M.B., Tebaldi, C., Mastrandrea, M.D., Falcon, W.P. and Naylor, R.L. Prioritizing climate change adaptation needs for food security in 2030. *Science* 319(5863): 607-610, 2008.

Moya, T.B., Ziska, L.H., Namuco, O.S. and Olszyk, D. Growth dynamics and genotypic variation in tropical, field-grown paddy rice (Oryza sativa L.) in response to increasing carbon dioxide and temperature. *Global Change Biology* 4: 645-656, 1998.

National Assessment Synthesis Team. 2001. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change.* Cambridge: Cambridge University Press.

Parry, M., Rosenzweig, C. and Livermore, M. Climate change, global food supply and risk of hunger. *Philosophical Transactions of the Royal Society of London B-Biological Sciences* 360(1463): 2125-2138, 2005.

Peng, S.B., Huang, J.L., Sheehy, J.E., Laza, R.C., Visperas, R.M., Zhong, X.H., Centeno, G.S., Khush, G.S. and Cassman, K.G. Rice yields decline with higher night temperature from global warming. *Proceedings of the National Academy of Sciences of the United States of America,* 101: 9971-9975, 2004.

Pleijel, H., Gelang, J., Sild, E., Danielsson, H., Younis, S., Karlsson, P.E., Wallin, G., Skarby, L. and Sellden, G. Effects of elevated carbon dioxide, ozone and water availability on spring wheat growth and yield. *Physiologia Plantarum*, 108: 61-70, 2000.

Reilly, J.M. and Graham, J. 2001. *Agriculture: The Potential Consequences of Climate*

Variability and Change for the United States. New York: Cambridge University Press.

Reilly, J., Tubiello, F., McCarl, B., Abler, D., Darwin, R., Fuglie, K., Hollinger, S., Izaurralde, C., Jagtap, S., Jones, J., Mearns, L., Ojima, D., Paul, E., Paustian, K., Riha, S., Rosenberg, N. and Rosenzweig, C. U.S. Agriculture and Climate Change: new results. *Climatic Change*, 57(1): 43-67, 2003.

Sato, S., Peet, M.M. and Thomas, J.F. Physiological factors limit fruit set of tomato (Lycopersicon esculentum Mill.) under chronic, mild heat stress. *Plant Cell and Environment,* 23: 719-726. 2000.

Schmidhuber, J. and Tubiello, F.N. Global food security under climate change. *Proceedings of the Natural Academy of Sciences of the United States of America (PNAS)* 104(50): 19703–19708, 2007.

Smith, S.J., Thomson, A.M., Rosenberg, N.J., Izaurralde, R.C., Brown, R.A. and Wigley T.M.L. Climate change impacts for the conterminous USA: An integrated assessment - Part 1. Scenarios and context. *Climatic Change*, 69: 7-25, 2005.

Southwick, S.M. and Uyemoto, J. 1999. *Cherry crinkle-leaf and deep suture disorders.*

University of California. Division of Agriculture and Natural Resources.

U.S. Census Bureau. 2005. *State Population Forecasts.* U.S. Census Bureau.

West, J.W. Effects of heat-stress on production in dairy cattle. *Journal of Dairy Science*, 86: 2131-2144, 2003.

Wheeler, T.R., Hadley, P., Morison, J.I.L. and Ellis, R.H Effects of temperature on the growth of lettuce (Lactuca sativa L.) and the implications for assessing the impacts of potential climate change. *European Journal of Agronomy*, 2: 305-311, 1993.

Ziska, L.H., Namuco, O., Moya, T. and Quilang, J. Growth and yield response of fieldgrown tropical rice to increasing carbon dioxide and air temperature. *Agronomy Journal*, 89: 45-53, 1997.

Chapter 4:
The Impact of BC Agriculture on Global Warming

Chapter Two examined the potential impact of climate change on food production in BC. Given that agriculture is a source of greenhouse gas (GHG) emission, and GHGs impact climate change, this chapter examines how agriculture production in BC can contribute to climate change. At the outset it is important to note that little information is available on emissions directly related to BC's agriculture sector. Therefore, the first section describes the link between agriculture and GHG emissions at a global level. The second section describes this issue in the Canadian context and the third section reviews the information available in BC, including some of the initiatives currently underway to plan for a reduction in emissions.

GHG Emissions from Agriculture - Global Contribution

In 2005, anthropogenic (human caused) GHG emissions from agricultural activity accounted for 10 to 12 percent of total global emissions (IPCC, 2007). The most significant greenhouse gases produced by agriculture are carbon dioxide (CO2), nitrous oxide (N20), methane (CH4) and nitrate (NH3) (Cole et al., 1997; IPCC, 2001; Paustian et al., 2004). While agriculture accounts for only about 10 percent of global GHG emissions, the sector is responsible for approximately 60 percent of N2O and 50 percent of CH4 emissions. This is important as both N2O and CH4 have greater radiative effects than CO2 and therefore contribute more to global warming than CO2 emissions (IPCC, 2001).

The main sources of GHGs from agriculture arise from decomposition of organic matter including plant litter, soils and manure (National Inventory Report, 2007). Carbon dioxide is released primarily from microbial decay, or burning of plant litter and soil organic matter (Janzen, 2004). The most prominent sources of methane are fermentative digestion of ruminant animals (including cattle, goats, sheep and bison), stored manure and rice grown under flooded conditions (Mosier, 1998). Decomposition of organic materials under oxygen-poor conditions also produces methane. Nitrous oxide is emitted during the transformation of nitrogen in soil and manure by microbes, a process that is greatly enhanced by the addition of nitrogen fertilizers to agricultural lands. Emissions of N2O are greater when vegetation is nitrogen-saturated, especially under wet conditions (Ellert and Janzen, 2008).

The agricultural sector's impact on climate becomes a concern in a world with an ever increasing human population and related demand for increased food – particularly some types of food demanded by increases in wealth (Desjardins, Sivakumar and de Kimpe, 2007). As populations in developing nations become more prosperous, diets tend to shift towards increased meat, dairy and fats. To the extent that these shifts involve increased demand for higher GHG producing animals (e.g., beef) and crops (e.g., rice) there is the potential

of amplifying agriculture's global contributions to climate change (IPCC, 2007). In other words, global demographic and economic trends all point to future increases in GHG emissions from agriculture.

Since arable land is limited, existing lands will need to increase yields to meet the ever-growing demand for "western" diets. This means that future food production will likely require more intensive farming methods, which tend to generate more GHG emissions. As well, these intense methods usually require greater application of fertilizer, which generates more nitrous oxide. Without changes to agricultural practices, it is estimated that by 2030 the global agricultural sector could attain the same level of GHGs as are currently emitted from all sources. (Vergé, de Kimpe and Desjardins, 2007).

GHG Emissions from Agriculture - Canadian Contribution

Canada contributes about 2 percent to total global GHG emissions. We are one of the highest per capita emitters, largely due to our landmass, climate and resource-based economy. In the period from 1990 to 2004, our emissions increased faster than almost any other developed nation (Greenhouse Gas Division, 2006). This inventory is not comprehensive as emissions from the distribution of agricultural products and emissions from on-farm energy use are omitted. In Canada, 2006 agricultural emissions accounted for 62 Mt (8.6 percent) of total GHG emissions, an increase of approximately 20 percent since 1990. Nitrous oxide accounted for about 56 percent of Canadian agriculture's emissions and methane for about 44 percent (Greenhouse Gas Division, 2006).

The main emissions-generating activities in the agricultural sector are animal production, cereals production and on-farm fuel use. In 2006, these activities accounted for 61 percent, 29 percent and 10 percent respectively, of all agricultural emissions in Canada (Greenhouse Gas Division, 2008). As well, between 1990 and 2006, animal production accounted for 80 percent of the increase in agricultural emissions (Greenhouse Gas Division, 2008).

Major GHG emitting activities occur in Alberta (livestock), Saskatchewan (cereals) and Ontario (livestock) (Agriculture and Agri-food Canada, 2009). Compared to other provinces BC is not a large producer of agricultural products as BC operations are small relative to other regions of Canada.

GHG Emissions in Canada Due to Livestock, Dairy and Cereal Production

Animal production is responsible for about 60 percent of Canada's agricultural GHG emissions. In turn, enteric fermentation (the digestive process) is responsible for approximately 65 percent of animal emissions (24Mt in 2006). In Canada, beef cattle produce the greatest emission of methane gas (Vergé, Dyerb and Desjardins, 2008). The remaining sources of GHG emissions from agriculture are related to manure management (9 percent of animal emissions in 2006) and the subsequent emission of nitrogen from manure applied as fertilizer (16 percent) or deposited on pastures (10 percent).

The dairy industry is also a large emitter of GHGs. In terms of total GHG emissions the BC dairy industry ranks fourth out of the five regions across the country. GHG emissions from the BC dairy industry for N2O are 230 kt CO2 eq (10.6 percent of Canadian total), for CH4 they are 380 kt CO2 eq (17.5 percent) and for CO2 they are 90 kt CO2 eq (4.1 percent) (Vergé, Dyerb and Desjardins, 2008).

GHG Emissions Due to Fisheries and Aquaculture

Activities involved in producing seafood mainly contribute carbon dioxide emissions to the atmosphere. Life-cycle assessments suggest that about 90 percent of GHG emissions are due to fossil fuel burning during fishing (Tyedmers, Watson and Pauly, 2005). The remaining 10 percent of emissions occurs during fish processing, distribution and consumption. However, as fisheries decline, the amount of fuel required by a fleet to catch more distant offshore stocks increases (refs Tyedmers et al., 2005).

Direct fuel inputs vary greatly by fishery. Energy use is influenced by the type of fishing vessel, distance to the fishing grounds, weather, type of catching gear and preservation of the catch (Tyedmers, 2001; Tyedmers et al., 2005). For example, fisheries for small pelagic fish typically use 50 litres of fuel per tonne of fish landed (refs in Tyedmers et al., 2005) while higher value species (shrimp, tuna) can use more than 2,000 litres of fuel per tonne of fish landed (refs in Tyedmers et al. 2005).

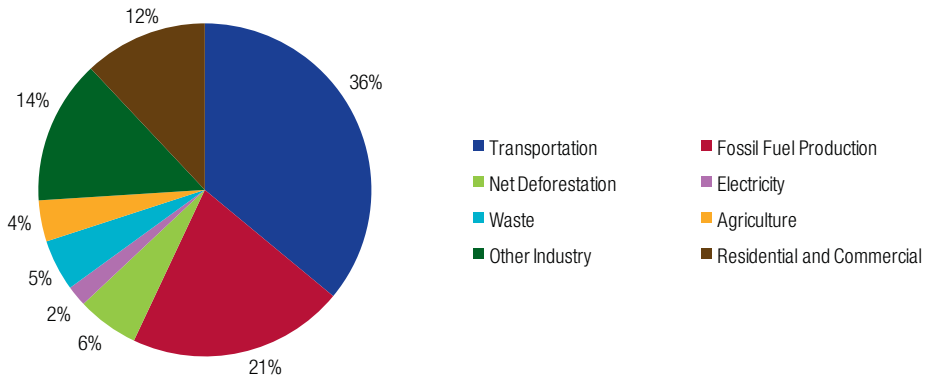
Aquaculture production also shows wide variability in energy inputs. Tlusty and Lagueux (2009) reviewed the energy costs associated with various forms of aquaculture production and found that this varied depending on the intensity of the farming operation and on the species farmed. Using edible protein returns (ratio of edible protein to industrial inputs), the energy performance of fisheries has been compared with other protein producing sectors (Tyedmers, 2001). Even the most intensive wild fisheries are more energy efficient than many livestock and intensive aquaculture systems. For example, wild salmon fisheries are 2.7 times more energy efficient for protein production than net pen aquaculture systems (Tyedmers, 2000).

GHG Emissions Due to Agriculture in British Columbia

On a per capita basis, BC is one of the lowest greenhouse gas emitters in North America, mainly due to the predominance of hydroelectricity in the province. Within Canada, we rank second lowest after Quebec. In 2004, BC's emissions intensity was 15.9 tonnes CO2 eq. per capita, almost one-third below the national average of 23.7 tonnes.

As shown in Figure 5, 2006 emissions from agriculture represent 4 percent of all emissions in the province (Live Smart BC, 2007).

Figure 5: BC Greenhouse Gas Emissions (2006)



(Live Smart BC, 2007) http://www.livesmartbc.ca/learn/emissions.html

According to the Live Smart BC report manure management accounts for 17 percent of emissions in this sector, agriculture (soils) accounts for a further 33 percent and livestock production accounts for 50 percent of emissions.

Action Currently Underway to Reduce GHG Emissions Due to Agriculture in BC

The Investment Agriculture Foundation of BC and the British Columbia Agriculture Council have jointly established an industry-led Climate Action Initiative Committee, which is working on a climate action plan for agriculture. In partnership with the Initiative, the BC Ministry of Agriculture and Lands, and the BC Climate Action Secretariat are identifying various GHG reduction and adaptation strategies for the agricultural sector. These include:

- facilitating the development of anaerobic digesters that utilize agricultural waste to produce biogas;
- exploring the role of agriculture in supplying carbon credits;
- developing programs to increase on-farm energy efficiency; and
- providing incentives for beneficial management practices that reduce emissions.

The initiative also develops tools and resources that provide information to agricultural producers on climate-related topics.

Conclusions

GHG emissions from agriculture account for approximately 10 percent of all global GHG emissions. In BC, agriculture accounts for only 4 percent of provincial GHG emissions. Overall, BC GHG contributions are low in both the global and Canadian context. This is due in part to our reliance on hydro electricity and the relatively small scale of agricultural operations in BC. Nonetheless, the sector is important because of its nitrous oxide and methane contributions, and their negative effects on global warming. Since most agricultural emissions are of these two gases, and about half the agricultural GHG emissions in BC are due to animal production, with another 17 percent due to off-gassing from manure, it is reasonable that GHG reduction strategies should focus on livestock production and management.

References

Cole, C.V., Duxbury, J., Freney, J., Heinemeyer, O., Minami, K., Mosier, A., Paustian, K., Rosenberg, N., Sampson, N., Sauerbeck, D. and Zhao, Q. Global Estimates of Potential Mitigation of Greenhouse Gas Emissions by Agriculture. *Nutrient Cycling in Agroecosystems*, 49(1): 221-228, 1997.

Desjardins, R.L., Sivakumar, M.V.K. and de Kimpe, C. The contribution of agriculture to the state of climate: Workshop summary and recommendations. Agricultural and Forest Meterology 142(4) 314-324, 2007.

Ellert, B.H. and Janzen, H.H. Nitrous oxide, carbon dioxide and methane emissions from irrigated cropping systems as influenced by legumes, manure and fertilizer. Canadian Journal of Soil Science, 88(2): 207-217, 2008.

Greenhouse Gas Division. 2006. *National Inventory Report: Greenhouse Gases Sources and Sinks in Canada*, 1990-2004. Environment Canada. Available online at http://www.ec.gc.ca/pdb/ghg/inventory_report/2004_report/toc_e.cfm

Greenhouse Gas Division. 2008. *National Inventory Report: Greenhouse Gases Sources and Sinks in Canada, 1990-2006*. Environment Canada. Available online at http://www.ec.gc.ca/pdb/ghg/inventory_report/2006_report/som-sum_eng.cfm#ts_2

IPCC. 2001. *Climate Change 2001: Impacts and Adaptation*. O. Canziani, J. McCarthy, N. Leary, D. Dokken, K. White (eds), Cambridge University Press, Cambridge, MA and New York, NY.

IPCC. 2007. C*limate Change 2007: The Scientific Basis, Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, England. Available online at http://www.ipcc.ch/ipccreports/ar4-wg1.htm

Janzen, H.H. Carbon cycling in earth systems - a soil science perspective. *Agriculture, Ecosystems & Environment,* 104(3): 399-417, 2004.

Lefebvre, A., W. Eilers and B. Chunn (eds). 2005. *Environmental Sustainability of Canadian Agriculture: Agri-Environmental Indicator Report Series – Report #2*. Ottawa: Agriculture and Agri-Food Canada.

LiveSmart BC. 2007. Climate Action Plan. Province of British Columbia. Available online at *http://www.livesmartbc.ca/government/plan.html*

Mosier, A.R. Soil processes and global change. *Biology and Fertility of Soils*, 27(3): 221-229, 1998.

Paustian, K., Babcock, B., Kling, C., Hatfield, J.L., Lal, R., Mccarl, B., Mclaughlin, S., Post, W.M., Mosier, A.R., Rice, C., Robertson, G.P., Rosenberg, N.J., Rosenzweig, C., Schlesinger, W.H., Zilberman, D. Climate change and greenhouse gas mitigation: challenges and opportunities for agriculture. *Council for Agricultural Science and Technology* (Task Force Report No. 141) 2004.

Tyedmers, P. Quantifying the Energy Consumed by North Atlantic Fisheries. In Pauly, D. and Pitcher, T.J. (eds). *Methods for Evaluating the Impacts of Fisheries on North Atlantic Ecosystems*. Fisheries Centre Research Reports, 8(2): 123-125. 2000. Available online at http://www.fisheries.ubc.ca/publications/reports/fcrr.php

Tyedmers, P. Energy Consumed by North Atlantic Fisheries. In Zeller, D., Watson, R.and Pauly, D. (eds.), *Fisheries Impacts on North Atlantic Ecosystems: Catch, effort and national/regional datasets*. Fisheries Centre Research Reports, 9(3): 12-34, 2001. Available online at http://www.fisheries.ubc.ca/publications/reports/fcrr.php

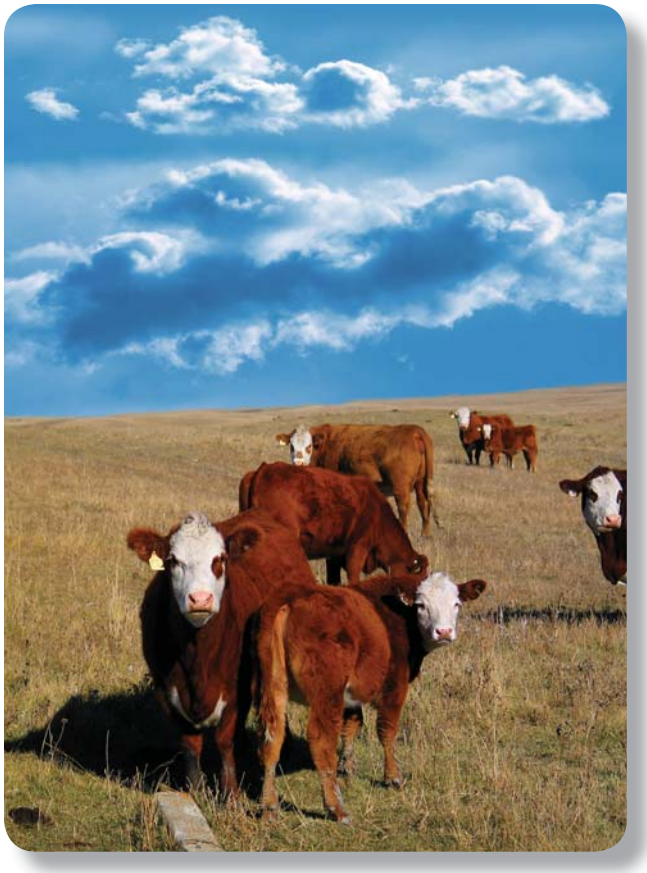
Tyedmers, P., Watson, R. and Pauly, D. 2005. Fueling Global Fishing Fleets. *A Journal of the Human Environment* 34(8): 635-638, 2005.

Tlusty, M.F. and Lagueux, K. Isolines as a new tool to assess the energy costs of the production and distribution of multiple sources of seafood. *Journal of Cleaner Production,* 17(3): 408-415, 2009.

Vergé, X.P.C., de Kimpe, C. and Desjardins, R. Agricultural production, greenhouse gas emissions and mitigation potential. *Agricultural and Forest Meteorology*, 142: 255-269, 2007.

Vergé, X.P.C., Dyerb, J. and Desjardins, R. Greenhouse gas emissions from the Canadian beef industry. *Agricultural Systems*, 98(2): 126-134, 2008.

Chapter Five:
Food Miles and Climate Change



The miles that food travels, from farm to fork, have an impact on climate change and food security in the province. Concern is growing over the sustainability of a global food system and the possible adverse impacts of long food supply chains on environmental health (Lang and Heasman, 2004). To measure greenhouse gas (GHG) emissions from all links in a given food supply chain several methods have been developed. These methods include energy accounting (Carlsson-Kanyama, Ekström and Shanahan, 2003), economic valuation (Pretty et al., 2001), ecological footprint analysis (Rees, 2003), carbon accounting (Lal, Griffin, Apt, Lave and Morgan, 2004), sustainability indicators (Capolrali, Mancinelli and Campiglia, 2003) and life-cycle assessment (Carlsson-Kanyama, 1998).

While methods have become more sophisticated for estimating the GHG emissions of various links in the food supply chains, discussions on food miles remain focused on the direct impact of transporting food from farm gate, or processing facility, to the consumer. This focus tends to discount the GHG emissions produced during the food production cycle, though research shows that for some food, the food production stage contributes more GHG emissions than does the food distribution stage. In order to shift policy to reduce emissions from particular food chains, GHG emissions analyses should be conducted for all stages of the food chain, instead of simply focusing on food miles (transport from farm gate to retailer or consumer) (Jones, 2002b).

To better understand the impact of food miles on GHG emissions in BC, the first step is to identify the longest food chains in the province. In Chapter Three, we identified fish, fruit and vegetables as the foods most imported into and exported from BC. While there is limited research information available on GHG emissions from fish food chains, a small body of work exists, mainly from Europe, on GHG emissions from various vegetable and fruit import chains.

This chapter begins with a review of the evidence of what the BC government is currently doing on the “food miles” policy front, followed by a discussion on the lengthening of food chains. Next the relative impact on GHG emissions from the food miles component of food production/distribution is examined. Section four identifies BC foods that are shipped the longest distances and policy directions that could reduce their length. The fifth section reviews the international evidence that might underpin the policy directions previously identified.

Food Miles and Policy to Improve Food Security in British Columbia

Two fairly recent government documents discuss the environmental impacts of long food chains in BC. These are the BC Agricultural Plan and the 2005 Report of the Provincial Health Officer. For economic reasons, specifically to support local farmers and stimulate markets for local foods, the Ministry of Agriculture and Lands (MAL) aims to increase consumer confidence in local products through a new industry-led marketing program. As part of this effort MAL is planning to launch a food miles program to help inform consumers of how far their food has traveled from field to plate, encourage direct farmer-consumer sales to reduce food miles and raise public awareness about farming to promote local produce.

The Provincial Health Officer's report includes a section dedicated to local food production and food miles and notes that the food industry in BC only supplies about half the food needed in the province. As an extreme example of this trend, over the last 50 years Vancouver Island has shifted from producing 90 percent of the food consumed on the island to only 10 percent.

Relying heavily on food imports negatively affects food security as it weakens the local agricultural economy, reduces support for the local food production and distribution sectors and potentially exposes British Columbians to disruptions in the global food system. The report also notes that although affordability of imported foods is appealing to consumers, the benefits of local production, the loss of local jobs and the environmental costs of food miles may help offset the appeal of low prices on some imported food.

The report goes on to state, "To support a local food supply and provide healthy, nutritious food for the population, there must be an infrastructure in place that supports local farmers and food producers" (p. 24). A healthy local food system can be supported by initiatives such as the Linking Land and Future Farmers group and the Small Scale Food Processors Association.

In reference to GHG emissions the report notes, "The further food travels, the more it contributes to increased carbon dioxide emissions and global warming" (p. 25). Food traveling over long distances often requires extra packaging, which both increases the energy inputs of production and creates additional waste. "A study in the United Kingdom found that the real cost of a market basket of food would be 11.8 percent higher per week if the true cost of food miles in environmental and societal factors was included in the price" (Pretty, Ball, Lang and Morison, 2005. p. 25).

No information from BC on the actual GHG emissions of local or import food chains in the province was utilized in these reports. The reports support a shift to local production and supply systems based on economic and social benefits, rather than on evidence on GHG emissions. A reduction of food miles benefits local landscapes, farmers and rural regions of BC. Short and local food chains, as opposed to long and import-based chains, would reduce dependence on foreign sources and increase control over food safety and production standards.

As suggested by the report's authors, promotion of local food systems with shorter food supply chains can improve food security by improving local economies and control over food safety. It may be correct to promote the move to local self-sustaining systems of food production for these reasons. However, it is also important to take a holistic approach by considering GHG emissions from all links in the food chain, and not just the transportation from farm to retailer or consumer.

The Increasing Length of Food Supply Chains

Several studies from the UK show that in recent decades, food supply in the UK has become more transport intensive due to increases in food imports, road freight distribution and shopping trips by consumers traveling in their cars (Jones, 2002a). Jones (2002b) estimated that the energy required for moving food in the UK is equivalent to 8 percent of annual per capita domestic energy consumption.

One study estimated that in 1992 UK food miles for imported food and animal feed were double the figure for food freight movements inside the country (Cowell and Clift, 1996). Between 1978 and 1993 food, drink and tobacco products accounted for one-third of the growth in road freight. While the amount of food product distributed remained static, the distance that these foods were transported increased by 50 percent (Paxton, 1994).

As well as increased food distribution miles, there has been growth in the number and length of shopping trips undertaken by consumers in their cars. Between 1985/86 and 1996/98 the distance of car shopping trips in the UK increased by 57 percent and the average number of shopping trips increased from 1.65 to 2.42 per person (Jones, 2002b).

These data reflect similar trends in other developed nations and indicate the increasing globalization and intensification of food supply chains in the past two decades. Food being transported more frequently over longer distances has led to an increase in GHG emissions and it is important for policy makers to review these changes in the context of the entire food chain.

Food Production/Distribution and GHG Emissions

Using American data on household food expenditure and life cycle assessment methods, Weber and Mathews (2008) calculated the total GHG emissions due to food production and distribution in 2006 at 8.1 tons (t) CO2 equivalent per year, per household. The transport of food accounted for 0.91 t CO2 equivalent per year, per household, or 11 percent of total GHG emissions due to food production and distribution. Another 0.36 t CO2 equivalent per year, per household, was due to transport of food from the farm gate or production facility to retail outlets. This latter distance is the way in which food miles is usually conceptualized and indicates that in the United States food miles only account for about 4 percent of the total GHG emissions from food production and distribution.

Measured both directly and indirectly these data indicate that the production side of the food supply equation contributes much more to GHG emissions than does food transportation. Adaptive policy decisions in agriculture should consider the context of the entire GHG emission spectrum from production to consumption. Shifting from a long to a short food supply chain may involve new farmers and producers. If they use more energy and GHG intensive methods of production, these could outweigh the benefits this shift would generate.

Since the GHG emissions spectrum across the production/distribution continuum differs according to type of food, further complications could arise. For example, Weber and Mathews have shown that in the United States, GHG emissions from transport account for a low of 1 percent for red meats, to a high of 11

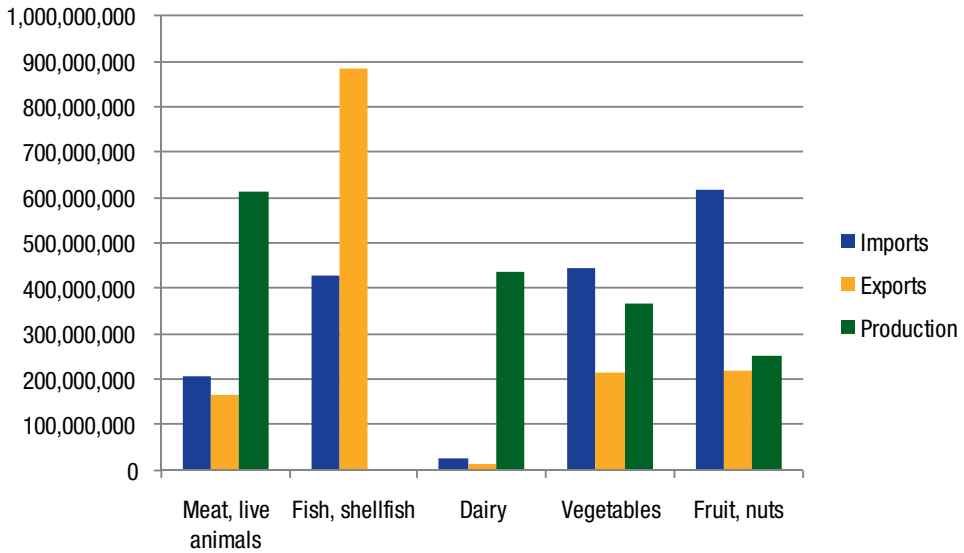
percent for fruits and vegetables. Yet the intensity of red meat production results in higher overall emissions compared to lower emissions for the less intense production of fruit and vegetables.

Several interesting studies of vegetable and meat food chains have been undertaken by Carlsson-Kanyama in Sweden. In an investigation of GHG emissions related to production and transport of pork, carrots, tomatoes, potatoes and dried peas, transportation accounted for a low of 4 percent of emissions for dried peas to a high of 31 percent for potatoes. In Sweden "transportation was not a large contributor to the total emissions of GHGs" for these products (Carlsson-Kanyama, 1998a, p.286). The main contributor to GHG emissions from these crops arose from winter storage and/or from fertilizer input during the growing season.

Long Food Chains in BC

As shown in Figure 6 and discussed in more detail in Chapter Three, most dairy, poultry and egg production in BC is local. Food chains for milk, cheese, eggs and chicken do not extend outside the province and are likely to be relatively short.

Figure 6: Approximate Value in Canadian Dollars of Foods Imported Into, Exported From and Produced In British Columbia in 2007



Imports and exports data:
Source: Industry Canada. 2007. "Trade Data Online (TDO) By Product.
http://www.ic.gc.ca/sc_mrkti/tdst/tdo/tdo.php. Canadian $.

Production data:
Statistics Canada CANSIM Table 002-0001. Farm Cash Receipts, 2007.
http://estat.statcan.gc.ca/cgi-win/cnsmcgi.exe?Lang=E&EST-Fi=EStat/English/CII_1-eng.htm

A large amount of fish is produced within the province, both for local consumption and export. In 2007, fish exports amounted to approximately $1 billion while fish imports were valued at just over $600 million. As significant amounts of fish are either imported from or exported to Asia, they are likely among the longest food chains in the province.

Imports of fruit are similar in value to fish, while imports of vegetables are somewhat less than fruit. Fruit and vegetable exports are substantial, although much less in value than imports of these products. The three major sources of imported fruits and vegetables to BC are the US, China and Mexico, making these long food chains.

While chains for fish, fruit and vegetables may be the longest in BC, it is important to note that length of chain is not the only issue. Mode of transport must also be addressed. Relative to road transport, for example, sea transport is highly efficient in terms of GHG emissions.

There is little international literature available on the GHG emissions of fish food chains, but information on fruit and vegetable chains is emerging. These studies have many different objectives ranging from promoting organic farming to proving the superiority of long transport routes for foods from New Zealand to Northern Europe. One way these studies can be utilized to improve understanding of food miles/GHG emissions is to identify specific policy questions that are relevant in the BC context.

Most importation of fruit and vegetables occurs during the winter months and importation from the most distant sources occurs in the period between November and March, when field-grown produce from the United States is less available. Therefore, reduction of fruit and vegetable imports in the winter months could reduce the length of some of the longest food chains and lower GHG emissions.

But what are consumers to do during the winter? Consumers could be educated to switch from fresh fruit and vegetables to processed, freeze-dried, frozen or otherwise preserved products, although it may be difficult to convince them to do so. An alternative might be to develop sophisticated bulk cold storage to keep some types of fruits and vegetables viable from harvest time to the deepest winter for fresh, or at least somewhat fresh, consumption. Still another alternative might be to produce vegetables and fruits in greenhouses during the BC winter. Research literature, coming mainly out of Northern Europe where there are similar winter fruit and vegetable supply challenges, may offer some insight into the GHG emission consequences of these three options.

Studies of Specific Food Chains in Relation to GHG Emissions

One way to supply produce in the winter for crops that store well, such as apples, is through long term storage following summer harvest. GHG emissions of winter imports of various fruits and vegetables from New Zealand to the UK have been compared to GHG emissions from these same fruits and vegetables that were harvested and then stored in the months prior to consumption (Saunders and Barber, 2008). A number of investigations show that conventional farms in New Zealand use approximately 50 percent less energy than equivalent farms in northern Europe (Barber, 2004; Basset-Mens, Ledgard and Carran, 2005). Two factors contribute to that efficiency: a) the milder climate produces higher yields and b) New Zealand generates almost two-thirds of its energy from renewable sources.

In a study of the production of apples and onions, Saunders and Barber (2008) noted that in New Zealand GHG emissions due to production were much lower than in the UK because of these efficiencies. As well, sea transport, even for long distances, is the least intensive form of transport in terms of GHG emissions.

Saunders and Barber found that GHG emissions for locally produced apples consumed in the UK winter were about two-thirds higher than they were for New Zealand apples imported into the UK. GHG emissions for apples imported from New Zealand to the UK during the winter were 185.0 kg CO2/Tonne compared to 271.8 kg CO2/Tonne for apples harvested in the fall in the UK, stored and consumed in winter. In this study high relative GHG emissions from UK apple production, in combination with high emissions due to electricity for cold storage through the fall and winter, were greater than the combined emissions from production and transport of apples from New Zealand. The GHG emissions from cold storage facilities accounted for about one-third of total GHG emissions. They found similar results for onions.

These results seem to favour New Zealand imports because of the unique production situation in that country. In particular, two-thirds of New Zealand's electricity is from clean hydro or geo-thermal sources, which greatly reduces GHG emissions in the production stage. Study results are also skewed in New Zealand's favour because of the use of the most GHG-efficient transportation method: ocean transport. If this study was repeated for another country with less efficient farms and production methods and with more road or rail transport, the results might favour growth and storage in the UK, rather than importation via a very long food chain.

Carlsson-Kanyama (1998b) undertook a study of food consumption patterns and their influence on climate change in Sweden. Using life-cycle assessment methods, the total GHG emissions from greenhouse grown tomatoes in Sweden, Denmark and Holland were compared to those from field grown tomatoes imported from Spain.

GHG emissions from the production of greenhouse tomatoes were highest for imports from Denmark. Denmark uses more coal for electricity generation (the source of greenhouse lighting and heating) than Sweden or Holland. GHG emissions from field tomatoes imported from Spain were less than one-quarter of the emissions from greenhouse tomatoes grown in Sweden. This was due to extremely high yields of field grown tomatoes in Spain and the relatively small amounts of fertilizer and other energy-intensive inputs. GHG emissions from storage, truck and rail transport were more than equalized by low GHG emissions in the production phase.

For many field grown crops the manufacture of fertilizer tends to be the production input with the greatest energy demand and associated GHG emissions (Oreland, Van Reseal and Roosevelt, 2005). If, as in the case of Spanish field tomatoes, these impacts are minimal, then GHG emissions can be quite low. In greenhouse production direct use of electricity for heating and lighting is the greatest contributor to GHG emissions (Williams, Ardsley and Saunders, 2006). Several authors report similar results when comparing local greenhouse tomato production in northern European winters with field grown tomato production and import from southern European countries (Wada, 1994).

Conclusions

There are many good reasons to promote reduced food miles to improve the food security of British Columbians. These include strengthening the local farm and food production system, re-vitalizing rural farming communities and strengthening communities in general. However, a food miles focus, particularly when narrowly conceived, is not the best way to frame GHG emission reduction policy. A better approach is to consider food chains in the entirety from production through to the final consumption of food.

Importing and exporting foods such as fish, fruits and vegetables form some of BC's longest food supply chains. To better understand the impact of these food chains on health and the environment, factors such as production, packaging, distribution, greenhouse gas emissions and energy consumption – from farm, to retailer, to consumer – need to be considered. Sophisticated cold storage methods, greenhouses that do not require high-energy input and consumers making better choices, present opportunities to promote sustainability in our food systems. Some of the issues policy makers will need to take into account to reduce BC's carbon footprint and support the agricultural and food sectors are as follows.

- Given high-energy inputs to modern farming, trade-offs in terms of GHG emissions, need to be calculated and considered for the whole length of the food chain.
- The longest food chains in BC, which should attract the greatest GHG emissions concern, are for fish imports. As GHG emissions information and research for this food chain is non-existent, this should be a priority for BC climate change and food security research.
- Other long food chains of concern are the winter chains for vegetable and fruit imports. Limited research literature indicates that if these food chains are shortened this must be done with the full understanding of the changes in GHG emissions wrought by using more local production and/or storage methods.
- Using greenhouse technology to provide vegetables and fruit during winter months must focus on the use of "clean" energy in order to render these types of local production adaptation methodology for reducing GHGs.

References

Barber, A. 2004. S*even Case Study Farms: Total Energy and Carbon Indicators for New Zealand Arable & Outdoor Vegetable Production.* AgriLINK New Zealand Ltd., 2004. Accessed May 04, 2009, from http://www.agrilink.co.nz/Portals/Agrilink/Files/Arable_Vegetable_Energy_Use_Main_Report.pdf.

Basset-Mens, C., Ledgard, S. and Carran, A. First Life Cycle Assessment of Milk Production from New Zealand Dairy Farm Systems. Paper presented to the *Australia New Zealand Society for Ecological Economics Conference* 11-13 December. Palmerston North: Massey University, 2005.

BC Ministry of Agriculture and Lands, 2006, *The British Columbia Agriculture Plan: Growing a Healthy Future for BC Families*. Victoria, BC.

Capolrali, F., Mancinelli, R., and Campiglia, E. Indicators of Cropping System Diversity in Organic and Conventional Farms in Italy. I*nternational Journal of Agricultural Sustainability,* 1(1): 67-72, 2003

Carlsson-Kanyama, A. Climate Change and Dietary Choices – how can emissions of greenhouse gases form food consumption be reduced? *Food Policy*, 23(3/4): 277-293, 1998a

Carlsson-Kanyama, A. Food Consumption Patterns and their Influence on Climate Change. *Ambio,* 27(7): 528-534, 1998b.

Carlsson-Kanyama, A. Ekström, M.P. and Shanahan, H. Food and Life Cycle Energy Inputs: consequences of diet and ways to increase efficiency. *Ecological Economics*, 44: 293-307, 2003.

Cowell, S., and Clift, R. *Farming for the Future: an environmental perspective.* Paper presented at the Royal Agricultural Society of the Commonwealth, July 1996.

Econet 1995

Jones, J.A. 2002a. *The Environmental Impacts of Distributing Consumer Goods: a case study on desert apples*. PhD Thesis (unpublished). Centre for Environmental Strategy, University of Surrey, Guildford, Surrey, UK.

Jones, A. An Environmental Assessment of Food Supply Chains: a case study on dessert apples. *Environmental Management*, 33(4): 560-576, 2002b.

Lal, R., Griffin, M., Apt, J., Lave, L., Morgan, M.G. Managing Soil Carbon. *Science*, 304: 393, 2004.

Lang, T. and Heasman, M. 2004. *Food Wars*. London: Earthscan.

Office of the Provincial Health Officer, 2005, *Provincial Health Officer's Annual Report 2005 • Food, Health and Well-Being in British Columbia*. Victoria, BC.

Paxton, A. 1994. *The Food Miles Report: the dangers of long distance food transport*. London: the SAFE Alliance.

Pretty, J., Brett, C., Gee, D., Hine, R.E., Mason, C.F., Morison, J.I.L., Raven, H., van der Bijl, G., Dobbs, T. Policy Challenges and Priorities for Internalising the Externalities of Agriculture. *Journal of Environmental Planning and Management*, 44(2): 263-283, 2001. 2001

Pretty, J.N., Ball, A.S., Lang, T. and Morison, J.I.L. Farm Costs and Food Miles: an assessment of the full cost of the UK weekly food basket. *Food Policy,* 30: 1-19, 2005.

Rees, W.E. Economic Development And Environmental Protection: An Ecological Economics Perspective. *Environmental Monitoring and Assessment,* 86(1): 29-45, 2003.

Roelandt, C., Van Wesemael, B. and Rounsevell, M. Estimating Annual N2O Emissions from Agricultural Soils in Temperate Climates. *Global Change Biology*, 11(10): 1701-1711, 2005.

Saunders, C. and Barber, A. Carbon Footprints, Life Cycle Analysis, Food Miles: global trade patterns and market issues. *Political Science*, 60(1): 73-88, 2008.

Wada, Y. Biophysical Productivity Data for Ecological Footprint Analysis. Report to the *UBC Task Force on Healthy and Sustainable Communities, Vancouver, 1994.*

Weber, C.L. and Matthews, H.S. Food Miles and the Relative Climate Impacts of Food Choices in the United States. *Environmental Science and Technology,* 42(10): 3508-3513, 2008.

Williams, A.G., Audsley, E. and Saunders, D.L. (2006). *Determining the Environmental Burdens and Resource Use in the Production of Agricultural and Horticultural Commodities.* [Main Report. Defra Research Project IS0205]. Bedford: Cranfield University and Defra.

Chapter Six:
The Built Environment, Local Government and Food Security

In the previous chapters we examined the impact income and climate change could directly and indirectly have on food security in BC. Food security is affected by a wide array of other factors, including the built environment. This chapter reviews the academic literature on the connection of the built environment to food security and identifies four main ways the built environment affects food security. It also highlights governmental and non-governmental organization initiatives in relation to food security and the importance of the Agricultural Land Reserve to food security in BC.

Over the years the built environment has gained growing recognition as a determinant of health. Jackson (2003) emphasizes, "We now realize that how we design the built environment may hold tremendous potential for addressing many of the nation's greatest current public health concerns, including obesity, cardiovascular disease, diabetes, asthma, injury, depression, violence and social inequities" (p. 1382). Weich et al. (2001) note that the built environment can affect health through direct physical as well as indirect social health impacts.

Defining the Built Environment

A lack of common agreement exists for a definition of the term "built environment." It is widely used in planning and public health literature, but is defined in various ways. For example, Handy et al. (2002) define the built environment as the combination of urban design, land use and the transportation system. Where urban design refers to physical elements of the landscape including public spaces, land use refers to distribution of land use activities over the landscape and the transportation system refers to roads, sidewalks and public transit. Dearry (2004) recognizes the built environment as "all of the physical structures built and engineered by people" (p. A600), including homes, work-places, schools, parks and transportation infrastructure. Papas et al. (2007) defines the built environment as encompassing "a range of physical and social elements that make up the structure of a community" (p.129). Finally, Weich et al. (2001) includes "housing form, roads and footpaths, transport networks, shops, markets, parks and other public amenities and the disposition of public space" (p. 284), as components of the built environment.

The Built Environment and Food Security

There is little guidance in the literature on the full impact the built environment can have on food security. Based on reading of the literature, the built food environment can be characterized in terms of:

1. the community food environment;
2. housing;
3. urban food growing environments;
4. school environments.

This chapter reviews the literature linking the community food environment, housing and urban food growing environments with food security.

The Community Food Environment

A common area of focus for research on food and the built environment is the spatial distribution of retail food outlets including convenience and grocery stores, supermarkets and restaurants, within a given region or community. The number, type, location and accessibility of these outlets are often investigated (e.g., Alwitt and Donley, 1997; Chung and Myers, 1999; Morland et al., 2002a, 2002b; Smoyer-Tomic et al., 2006; Hemphill et al., 2008; Glanz, 2009). It is in this literature that the term “food desert” is found, describing neighbourhoods with few or no food outlets (Beaumont et al., 1995).

Related to these studies are those using geographic information systems (GIS) to evaluate the distance between retail food outlets and consumers and between various types of restaurants and consumers (Cummins, 2007). In addition to GIS these studies utilize a variety of techniques to:

- count the density of, or the number and variety of retail food outlets in a neighbourhood (Morland et al., 2002; Cummins and MacIntyre, 2006; Moore and Diez Roux, 2006);
- classify the different types of retail food outlets in a neighbourhood;
- measure the distance from home or school location to the nearest retail food outlet, or the number of retailers available within a specific distance of home (Zenk et al., 2005b; Wang et al., 2008);
- evaluate the barriers to physically accessing retail food outlets such as income and mobility (Mojtahedi et al., 2008); and
- compare the availability of different kinds of retail food outlets across different types of neighbourhoods (Alwitt and Donley, 1997; Chung and Myers, 1999; Morland et al., 2002; Baker, 2004; Zenk et al., 2005b; Moore and Diez Roux, 2006).

These studies, mainly conducted in the United States within the past decade, indicate that healthy, affordable food is usually found in neighbourhoods with a high proportion of high-income earners and highly educated people (Larson et al., 2009). Some of this research has shown that neighbourhoods with poor community nutrition environments also tend to have a high proportion of both obese people and those with poor health

status (Papas et al., 2007; Moore et al., 2008; Story et al., 2008; Wang et al., 2008). Additionally, some of these studies have compared community nutrition environments of low versus high socio-economic status neighbourhoods (Smoyer-Tomic et al., 2006; Larsen and Gilliland, 2008). Many American studies focus on the community nutrition environments in ethnic, particularly black, neighbourhoods (Morland et al., 2002a, 2002b; Dalton, 2004; Zenk, et al., 2005a, 2005b). This literature is also heavily focused on urban environments, although there are some recent studies on the rural food environment (e.g., Sharkey and Horel, 2008; Sharkey, 2009). These latter studies are mainly concerned with how people of low-income and low-mobility (restricted access to affordable transportation) access food.

Articles examining links between the community nutrition environment and socio-economic status (SES) tend to measure:

- the number of grocery stores, supermarkets or fast food outlets in neighbourhoods with different SES profiles (Winkler et al., 2006);
- the availability of high quality foods, particularly fruits and vegetables, in neighbourhoods differing in SES (Bertrand et al., 2008);
- the clustering of certain negatively valued food outlets (fast food restaurants and grocery stores carrying limited produce) in neighbourhoods differing in SES (Zenk et al., 2005a, 2005b);
- the affordability of high-quality foods, including fruits and vegetables in neighbourhoods differing in SES (Smoyer-Tomic et al., 2008).

When long distances exist between homes and retail food outlets, difficulties with transportation are likely to arise. Holben et al. (2004) identify a link between hunger and a lack of reliable transportation options. This is a particular problem in rural areas where large distances and a lack of public transit make it difficult for people without vehicles to shop (Sharkey and Horel, 2008). Research from Australia suggests that access to adequate private transport had a greater effect on food access than did physical proximity to food stores (Coveney and O'Dwyer, 2009; Sharkey, 2009).

Many of the studies attempt to explore the relationship between the community nutrition environment and the nutritional status of the population (Story et al., 2008), dietary habits (Morland et al., 2002a; Sloane et al., 2003), shopping behaviours and obesity (Morland et al., 2006). These studies are inconsistent in their findings. For example, Morland et al. (2002b; 2006) noted higher rates of obesity and greater access to unhealthy foods in neighbourhoods with more supermarkets. In other studies undertaken in the UK, Australia and Canada poor diet and low nutritional status were not associated with price, food availability or proximity to food outlets, suggesting that food retail access in urban areas may exert little effect on food security (Turrell et al., 2004; Pearson et al., 2005; Cummins et al., 2005; Inglis et al., 2005; Ball et al., 2006).

Another sub-set of studies focuses on food pricing and availability, in particular urban or rural environments and/or in particular kinds of stores (e.g., Jetter and Cassady, 2006; Liese et al., 2007; Creel et al., 2008). For example, in neighbourhoods served by smaller grocery stores, access to healthier food products was lower and the products were more expensive (Jetter and Cassady, 2006). Many of these studies compare food pricing and availability to nutrition levels, dietary habits or shopping behaviours and obesity (Turrell et al., 2004; Zenk et al., 2005a; Glanz et al., 2007; Casey et al., 2008; Pettinger et al., 2008). Marketing and promotion of food in relation to nutrition and shopping behaviour was also investigated (Whelan et al., 2002;

Goldberg and Gunasti, 2007). One article was found addressing the physical design of grocery stores and supermarkets and its effect on food accessibility for customers in wheelchairs (Mojtahedi et al., 2008).

The variation of results in studies linking the built environment and food security has focused research attention on study methods (Cummins, 2007; Papas et al., 2007; Elinder and Jansson, 2009; Glanz, 2009; Lytle, 2009; McKinnon et al., 2009). Elinder and Janson (2009) note that quantitative studies measuring the distribution of food outlets across neighbourhoods with different socio-economic status do not account for "real-world 'action-spaces' of individuals" (p. 310) who develop alternate strategies to deal with a lack of access to affordable healthy foods in their neighbourhoods (Cummings, 2007). They note that this oversight in some studies might account for the inconsistency of results between studies on community nutrition environments.

Canadian Studies on the Built Environment and Food Security

Studies that related the built environment to aspects of food security have been completed in Montréal, QC (Bertrand et al., 2008); Vancouver, BC (Broughton et al., 2006); London, ON (Larsen and Gilliland, 2008); Fort Albeny First Nation, ON (Skinner et al., 2006); Edmonton, AB (Smoyer-Tomic et al., 2006, 2008); Nova Scotia and several First Nations communities in Western Ontario (Gittelsohn and Sharma, 2009). Table 2 below provides a short synopsis of these studies.

Table 2: Summary of Methodology and Results of Canadian Studies on the Effect of the Built Environment on Food Security

Study	Location	Main objectives	Methodology	Results
Larsen and Gilliland 2008	London, ON	Explore the evolution of food deserts in a mid-sized Canadian city.	Uses GIS to map precise locations of supermarkets in 1961 and 2005; network analyses assessed changing levels of supermarket access in relation to neighbourhood location, socio-economic characteristics and access to public transit.	Residents of inner-city neighbourhoods of low SES had poorest access to supermarkets. Authors concluded that urban food deserts exist in London, Ontario.
Smoyer-Tomic et al., 2006	Edmonton, AB	Determine supermarket accessibility within the city.	Used a GIS to calculate minimum distance and coverage methods (shortest network path).	Subset of urban neighbourhoods with unsupportive local food environments.
Smoyer-Tomic et al., 2008	Edmonton, AB	Examine whether exposure to supermarkets and fast food outlets varies with neighbourhood level SES.	Used a GIS to calculate the number of supermarkets and outlets within street network distance of the geometric centre of 215 census blocks + weighted mean minimum distance. Regression analysis examined relationships among variables.	Low wealth, renter-occupied and lone-parent neighbourhoods had greater exposure to fast food outlets that was not offset by better supermarket access.

Study	Location	Main objectives	Methodology	Results
Apparicio et al., 2007	Montréal, QC	Assess to supermarkets.	Used GIS to calculate proximity, diversity and variety in accessibility of supermarkets. Applied cluster analysis to 3 accessibility measures.	No difference between neighbourhood access to supermarkets.
Gittelsohn and Sharma 2009	First Nations, Western Ontario	Explore the food environment in disparate low-income settings.	Field observations.	Low proximity to food stores/ supermarkets, cost and limited availability of healthful food.
Travers, 1996	Nova Scotia	Examine social organization of nutritional inequalities among disadvantaged urban women and their families.	Participant observation of food and nutrition practices in homes; interviews.	Limited access to inexpensive stores made buying food complicated. Reliance on charity for food.
Veugelers et al., 2008	Nova Scotia	Examine if access to healthy food and physical activity spaces affects diet, activity level and weight in children.	Children and parents completed questionnaires. Multivariate statistics used to examine relationships among variables.	Demonstrated associations between neighbourhood characteristics, healthy behaviours and childhood weight.
Skinner et al., 2006	Fort Alberny First Nation, ON	To investigate barriers and supports for healthy eating and physical activity in youth in a remote sub-arctic community.	A qualitative multi-method participatory approach.	Empowerment is a core issue that should be considered in the design of public health interventions for First Nations youths in remote sub-arctic communities.
Broughton et al., 2006	Vancouver, BC	Measure and determine association between household security and food environment, and nutritional status of children.	Survey of kitchen skills and appliances, perceived food quality. Convenience sample of households.	Household food insecurity was associated with indicators of suboptimal health in children. Parents with less access to food of reasonable quality, fewer kitchen appliances and lower self-rated cooking skills had greater food insecurity.
Bertrand et al., 2008	Montréal, QC	Evaluate disparities in access to healthy food; focus on fruits and vegetables (f/v).	Used GIS to calculate a custom accessibility index. Motorized and non-motorized consumers were analyzed in dissemination areas (DA) on the island of Montréal. Regression analysis to examine relationship b/n f/v availability and DA SES.	Fruit and vegetable access is not sufficient for 40 percent of Montreal. There was no relationship between SES of neighbourhoods and access to fruits and vegetables.

Study	Location	Main objectives	Methodology	Results
Hemphill et al., 2008	Edmonton, AB	To explore the relationship between the placement of fast-food outlets and neighbourhood-level socio-economic variables by determining if indicators of lower SES were predictive of exposure to fast food.	Discriminant function analysis was used to determine association between neighbourhood demographics and accessibility of fast-food outlets.	Significant differences were found between the three levels of fast-food accessibility across the socio-economic variables, with successively greater percentages of unemployment, low income and renters in neighbourhoods with increasingly greater access to fast-food restaurants.

These Canadian studies show that the availability and access to food are reduced when neighbourhoods do not have easily accessible retail outlets that sell healthy food. Poorer neighbourhoods tend to have reduced access to healthy, well priced foods. These studies are mainly focused on access to food rather than dietary habits or nutritional status of Canadians living in neighbourhoods with built environments with limited food availability.

Housing and Food Security

Housing is part of our everyday built environment through which wide ranges of determinants operate and mediate our health throughout our lifetime (CMHC, 2002). Housing impacts our food security in four main ways.

- Access to food retail outlets, food services such as food banks and restaurants is influenced by housing location and the availability of transportation (CMHC, 2002).
- Housing design, kitchens in particular, impacts food security when lack of proper storage and cooking facilities constrains food purchasing and preparation.
- When housing is expensive and incomes low there is less disposable income for food purchase (Vancouver Coastal Health, 2008).
- Access to housing and food security programs may help promote community capacity building, reducing the sense of isolation and improving health status and access to food (Bouchard et al., 2005; PHSA, 2007).

When housing costs are high and people living in poverty are food insecure, cheaper, unhealthy foods are often chosen based on high caloric intake (Provincial Health Officer's Annual Report, 2005). Low-income households purchase significantly fewer fruits, vegetables and milk products than high-income households in Canada (Kirkpatick and Tarauk, 2003). A recent study in Washington State found food costs for healthy items have increased up to 20 percent over the past two years while less healthy food costs dropped by 2 percent (Monivais and Drewnowski, 2007). Despite the current economic downturn the trend of higher house prices, rents and food prices may lead to greater housing-related food insecurity.

According to the Provincial Health Officer's 2005 Annual Report, low-income populations may also face geographic barriers to healthy, nutritious food due to lack of personal transportation, and the cost and limited range of public transit. The elderly and disabled populations, with limited mobility and poor housing circumstances, are even further hindered in their ability to obtain nutritious food.

People at particular risk are those living in single room hotels or other basic accommodations in the downtown cores of cities like Victoria and Vancouver. These people may have limited cooking, preparation and storage facilities in their rooms. This hampers the ability of low-income households to buy food in bulk and cook economically (Provincial Health Officer's Annual Report, 2005).

Vancouver Coastal Health (2009) offers some excellent evidence on the link between housing and food security in a recent survey conducted in Vancouver's Downtown Eastside (DTES). There are an estimated 16,000 residents in the DTES, one of the poorest neighbourhoods in Canada. In the survey, 47 residents of the area were interviewed about housing and food security, along with 18 food and housing providers. Survey results showed several conditions contributing to food insecurity. These included difficulty accessing food on weekends, holidays and at night when most food programs are closed. The homeless and marginally housed (in single rooms for example) were the most dependent upon free or low cost food providers in the area. Providing food in-house would reduce the need to go outside the building to access food and would improve food security.

Food and housing providers recommend more food programs that are sensitive to individual needs and capabilities, with the understanding that these will change over time. For those with severe addictions and/or mental health problems for example, on-site food provision could be accomplished through a cafeteria or a food delivery program. This would require consciously linking food security into the design and construction of housing. It was also noted that as physical and mental conditions improve, it is important to provide a range of options to access food, including in-room cooking facilities and/or community kitchens. Minimum recommendations for in-room facilities are a bar fridge and microwave in order for residents to be able to store and heat meals. Community kitchens can provide an important transition between reliance on food provision and cooking for oneself.

Finally, it is crucial to pay attention to amenities available within the neighbourhood. Without easy access to free or inexpensive food in close proximity to their building, residents are likely to become more food insecure. The following is a summary of policy recommendations for housing and food security in the DTES.

- To ensure food security for residents all contracts for new or refurbished housing should include a plan incorporating the physical and mental health issues of the resident population, as well as available resources within close proximity of the site. Food programs within the building should be evaluated regularly to assess whether they meet the nutritional needs of the residents, whether the food is acceptable to the residents and if residents are obtaining new skills and knowledge through food programs, e.g., cooking skills through a community kitchen.
- Support food programs that deliver meals or provide meals in-house to improve access for those who have physical or mental health issues and/or active addictions. These issues make accessing food providers or cooking difficult. Where appropriate and feasible, utilize a community development model that involves residents in meal planning and cooking.
- Make cooking facilities a part of basic housing infrastructure. At minimum, provide a refrigerator and a microwave.
- In situations where in-room cooking facilities are not feasible, provide staffed communal kitchens where residents can plan meals and cook together on a regular basis.

- Make healthy food available free of barriers and where people are situated (e.g., the street), because the hard-to-house are often not housed.

Grey-area literature in BC is more instructive on the relationship between housing and food security than general academic literature, perhaps because of a unique combination of high house prices, high rent and high food prices. Nonetheless, searching academic literature did produce some articles on kitchen design and food security. For example, Sobal and Wansink (2007) identify components of "microscale built environments" related to eating behaviours including "kitchenscapes, tablescapes, platescapes, and foodscapes." Kitchen design and functionality can affect food choices by regulating the foods that can be prepared and stored. A Canadian study notes the availability of kitchen appliances, combined with lower access to food of reasonable quality and lower self-rated cooking skills, can affect household food security (Broughton et al., 2006).

The availability of adequate kitchen equipment, space and design may also limit an institution's ability to provide healthy food to clients. This may be a particular issue for captive or semi-captive populations, such as those in seniors' homes and in schools.

Urban Food Growing Environments

Growing food in urban spaces is an element of the built environment that could have a significant impact on food security (Alaimo et al., 2008). Many urban spaces would support gardens, including backyards, rooftops, balconies and windowsills. In the community at large, vacant lots, municipal parks, school grounds, boulevards and the rooftops of public buildings could be utilized to grow food.

In developed nations, the focus is often on urban gardening programs in low-income communities (Brown and Jameton, 2000). While urban agriculture is a valuable tool for meeting the food needs of low-income households, if implemented on a larger scale it could also improve the food security of larger urban populations and provide a local, sustainable source of fruits, vegetables and possibly even livestock (Doron, 2005). Several innovative urban agriculture initiatives from fruit tree gleaning (Hoisington et al., 2001), to urban farms (Vogl et al., 2004) and hydroponic greenhouses (Moron, 2006) are described in various papers. Many organized urban agriculture programs incorporate gardening education. A search on urban gardening found several articles that outline programs for children, youth and seniors (Hackman and Wagner, 1990; Graham and Zidenberg-Cherr, 2005). As well, a number of innovative gardening and composting programs have been developed in schools, especially in the United States. These school-based programs are reviewed in the next chapter.

Studies on urban agriculture and community gardening have linked better access to a higher intake of fruits and vegetables (Armstrong, 2000; Blair et al., 1991; Kamphuis et al., 2006; Morton et al., 2008; Twiss et al., 2003; Wakefield et al., 2007). Other studies noted participants in urban agriculture are able to save money on food purchases and stretch their food budgets (Caillavet et al., 1998; Doron, 2005; Hoisington et al., 2001; Vogl et al., 2004). And, urban agriculture can be a source of culturally appropriate fruits and vegetables in ethnic communities (Corlett et al., 2003; Wahlqvist, 2002).

Some cautionary notes were raised on the subject. Two articles drew attention to concerns around safety, especially with regard to contaminants in urban soils (Finster et al., 2004; Hough et al., 2004). Hamelin et al.

(2008) point out that urban agriculture is not a stand-alone solution to issues of urban food production. This point is also emphasized by the United States Department of Agriculture (Adeyemi, 2000).

Only a few Canadian studies on urban gardening were found in the literature (Baker, 2004; Hamelin et al., 2008; Mendes, 2008; Mendes et al., 2008; Wakefield et al., 2007). Baker (2004) describes the experience of community gardening in Toronto as playing a transformational role in the city's urban spaces, as well as benefiting a network of organizations working on food security issues.

Food Security and the Built Environment in BC

In 2007 the British Columbia Provincial Health Services Authority (PHSA) released a report on the relationship between the built environment and health. This report had an extensive section on food security. Using literature primarily from non-Canadian sources, the document identifies areas for policy development related to food security. These include:

- the need to consider economic, physical and policy environments in the development of policies to address food behaviours;
- the importance of physical location or point-of-purchase signage and economic factors (e.g., price signals) to encourage better food choices;
- the importance of school food environments in developing healthy eating habits; and
- the need for longitudinal studies linking economic, policy and physical environments to food choices.

The PHSA report focuses on the community and consumer nutrition environments rather than urban food growing and home food environments. The authors stress the importance of zoning and neighbourhood designs that support food access and healthy food choices with consideration to location of grocery stores, farmers' markets and restaurants. They also stress policy options that reduce the availability of unhealthy foods in institutional settings such as schools. Finally, they give brief reference to providing land for community gardens as a way to increase healthy food choices.

This was followed in 2008, by the PHSA publication *"A Seat at the Table: Resource Guide for Local Governments to Promote Food Secure Communities"* (BC Provincial Health Services Authority 2008). Following on from PHSA's 2007 report, this document laid out practical steps that municipalities might take to alter the built environment within their jurisdictions in ways that could improve food security. In particular, the report noted land use plans that expand urban spaces for gardening, composting and marketing local farm produce (farmers' markets), in conjunction with changes in municipal by-laws, can go a long way to improve food security in BC's cities and towns.

The Agricultural Land Reserve

Extensive work has been conducted in British Columbia to support the Agricultural Land Reserve (ALR), which was established in 1974 to:

- preserve agricultural land;

- encourage farming on agricultural land, in collaboration with other communities of interest; and
- encourage governments, their agents and first nations to accommodate farm use of agricultural land (Curran, 2005, 2009, Smart Growth, 2004, 2005, 2009).

BC has a unique institution in the ALR. Land in the ALR provides 50 percent of our food supply and acts as an urban containment boundary that encourages more compact communities (Smart Growth BC, 2004, 2005). A number of papers have been developed to help foster community and local citizen support in preserving the ALR (Smart Growth BC, 2005, 2009). As well, the West Coast Environmental Law Foundation has developed a guide to help researchers and municipalities work to preserve agricultural land (Curran, 2005, 2009). According to the report entitled *"What Can Local Governments Do to Protect and Enhance Local Agriculture"* (Curran, 2009), local governments have a key role to play in preserving land for agriculture. The report navigates local planners through complex legal and policy documents governing agriculture and identifies tools and legal authority available to local governments to preserve and enhance local agriculture.

The report shows how planning tools currently available to local governments can be used. In particular, the author recommends the development of Regional Growth Strategies for a long-term vision (over 20 years) of the Regional District. Within this plan, the development of Regional Context Statements linked to Official Community Plans is advocated. These Statements should contain Development Permit Areas, which outline areas in the local community where development is limited and licensed. These planning tools, in conjunction with Development Permits and Zoning by-laws, provide an opportunity to preserve farmland and shape urban development in ways that promote urban agriculture.

Given that the ALR is a fairly unique institution devoted to the preservation of both urban and rural land for farming, it is not surprising that a search on the built environment failed to produce many papers. However, a search of grey-area literature shows that this institution is very important in terms of food security in BC. This is particularly true where urban and suburban development is occurring on or near prime agricultural lands, close to heavily populated areas. Considering the impact of the built environment on food security, a unique integrated approach should be taken, with consideration given to using urban land for agriculture, in congested urban/agricultural spaces and in rural places.

The role of the ALR is key in framing discussions on the built environment and food security. Its preservation and expansion are important in a province like BC, with its combination of limited arable land and immense pressures for urban development. Land use decisions, in relation to food security, are particularly important in areas where urban development is encroaching on prime agricultural land. Even if efforts to expand urban agriculture are successful, the loss of rural and peri-urban prime agricultural lands to development may decrease our collective food security in the long run. Therefore, in any discussion of the built environment and food security, consideration of the ALR in BC is essential. The legal framework for the ALR and the legal and planning powers available to BC municipal governments have the potential, if well coordinated, to be much more effective than at present in enhancing and preserving agricultural land and food security in the province.

Conclusions

This chapter has focused on ways in which the built environment impacts food security. A review of the research reveals four ways to examine the "built environment" in relation to food security: the community nutrition environment, especially the physical design and spatial distribution of retail food outlets, housing,

urban agriculture and the school nutrition environment. The importance of the school nutrition environment to food security is discussed in the next chapter.

Conclusions are difficult to draw even after reviewing extensive research on proximity, location and spatial distribution of food outlets. Smaller Canadian studies appear to indicate that availability and access to food are reduced when neighbourhoods do not have easily accessible outlets that sell healthy food and this is more common in lower income neighbourhoods. Food security is a particular concern for our most vulnerable populations who lack transportation, affordable housing and access to both food and food programs.

In the past several years a number of initiatives have been undertaken to change the built environment to facilitate urban agriculture and support backyard and rooftop gardens, greenhouses and community plots. There has been a proliferation of farmers' markets, which have proven to be good for people and local economies. Municipalities have a major role to play in making urban spaces more agriculture-friendly, notably through enhanced planning and by-law modifications.

Expansion of urban agriculture and preservation and expansion of peri-urban and rural lands through the ALR will increase the food security of British Columbians. Increasingly all stakeholders will need to consider geographically and jurisdictionally separate areas as a whole, in order to move forward and promote overall food security in BC.

References

Adeyemi, A. (2000). *Urban agriculture: An abbreviated list of references and resource guide 2000*. http://www.nal.usda.gov/afsic/AFSIC_pubs/urbanag.htm

Alaimo, K., Packnett, E., Miles, R.A. and Kruger, D.J. (2008). Fruit and vegetable intake among urban community gardeners. *Journal of Nutrition Education and Behavior,* 40(2), 94-101.

Alwitt, L. and Donley, T. (1997). Retail stores in poor urban neighborhoods. *Journal of Consumer Affairs*, 31(1), 139-164.

Apparicio, P., Cloutier, M.S. and Shearmur, R. (2007). The case of Montreal's missing food deserts: Evaluation of accessibility to food supermarkets. *International Journal of Health Geographics*, 6, 13.

Armstrong, D. (2000). A survey of community gardens in upstate New York: Implications for health promotion and community development. *Health & Place*, 6(4), 319-327.

Baker, L.E. (2004). Tending cultural landscapes and food citizenship in Toronto's community gardens. *Geographical Review*, 94(3), 305-325.

Ball, K., Crawford, D. and Mishra, G. (2006). Socio-economic inequalities in women's fruit and vegetable intakes: A multilevel study of individual, social and environmental mediators. *Public Health & Nutrition*, 9(5), 623–630.

BC Provincial Health Services Authority (2007). *Creating a healthier built environment in British Columbia*. Vancouver.

BC Provincial Health Services Authority (2008). *A seat at the table: Resource guide for local governments to promote food secure community*. Vancouver.

Beaumont, J., Lang, T., Leather, S. and Mucklow, C. (1995). *Report from the policy sub-group to the Nutrition Task Force Low Income Project Team of the Department of Health.* Radlett, Hertfordshire: Institute of Grocery Distribution.

Bertrand, L., Therien, F. and Cloutier, M.S. (2008). Measuring and mapping disparities in access to fresh fruits and vegetables in Montréal. *Canadian Journal of Public Health-Revue Canadienne De Santé Publique*, 99(1), 6-11.

Blair, D., Giesecke, C.C. and Sherman, S. (1991). A dietary, social and economic evaluation of the Philadelphia Urban Gardening Project. *Journal of Nutrition Education*, 23(4), 161-167.

Bouchard, L., Roy, J.F., and van Kemenage, S. 2005. *What impact does social capital have on the health of Canadians?* Policy Research Initiative (PRI). Ottawa: Government of Canada.

Broughton, M.A., Janssen, P.S., Hertzman, C., Innis, S.M. and Frankish, C.J. (2006). Predictors and outcomes of household food insecurity among inner city families with preschool children in Vancouver. *Canadian Journal of Public Health-Revue Canadienne De Santé Publique*, 97(3), 214-216.

Brown, K.H. and Jameton, A.L. (2000). Public health implications of urban agriculture. *Journal of Public Health Policy*, 21(1), 20-39.

CMHC (2002). *The population health approach to housing: a framework for research. Canada Mortgage and Housing Corporation*. Ottawa. Retrieved June 11th, 2008 from http://ftp.chmc-schl.gc.ca

Caillavet, F., Nichele, V. and Robin, J.M. (1998). Modelling the consumption of home-produced vegetables with an application to French households. *European Review of Agricultural Economics,* 25(2), 170-187.

Casey, A.A., Elliott, M., Glanz, K., Haire-Joshu, D., Lovegreen, S.L., Saelens, B.E., et al. (2008). Impact of the food environment and physical activity environment on behaviours and weight status in rural US communities. *Preventive Medicine*, 47(6), 600-604.

Chung, C. J. and Myers, S.L. (1999). Do the poor pay more for food? An analysis of grocery store availability and food price disparities. *Journal of Consumer Affairs*, 33(2), 276-296.

Corlett, J.L., Dean, E.A., and Grivetti, L.E. (2003). Hmong Gardens: Botanical diversity in an urban setting. *Economic Botany,* 57(3), 365-379.

Coveney, J. and O'Dwyer, L. A. (2009). Effects of mobility and location on food access. *Health & Place,* 15(1), 45-55.

Creel, J.S., Sharkey, J.R., McIntosh, A., Anding, J. and Huber, J. C. (2008). Availability of healthier options in traditional and non-traditional rural fast-food outlets. *BMC Public Health*, 8, 395.

Cummins, S. (2007). Neighbourhood food environment and diet - Time for improved conceptual models? *Preventive Medicine,* 44(3), 196-197.

Cummins, S. and Macintyre, S. (2006). Food environments and obesity - Neighbourhood or nation? *International Journal of Epidemiology,* 35(1), 100-104.

Cummins, S., Petticrew, M., Higgins, C., Findlay, A. and Sparks, L. (2005) Large scale food retailing as an intervention for diet and health: Quasi-experimental evaluation of a natural experiment. *Journal of Epidemiology & Community Health*, 59, 1035-1040.

Curran D. (2005). Protecting the working landscape of working agriculture: A Smart Growth direction for municipalities in British Columbia. *West Coast Environmental Law Research Foundation*. Victoria, BC. http://www.wcel.org/wcelpub/2005/14233.pdf

Curran D. (2009). What can and should local governments do to protect and enhance local agriculture? *CRD Roundtable on the Environment: Food and Agriculture Subcommittee*. Victoria, BC. http://www.crd.bc.ca/rte/documents/RTEAgriculturalLegalandPolicyAnalysis2009.pdf

Dalton, S. (2004). Schools and the rising rate of overweight children: Prevention and intervention strategies. *Topics in Clinical Nutrition*, 19(1), 34-40.

Dearry, A. (2004). Impacts of our built environment on public health. *Environmental Health Perspectives*, 112(11), A600-A601.

Doron, G. (2005). Urban agriculture: Small, medium, large. *Architectural Design,* 75(3), 52-59.

Elinder, L.S., and Jansson, M. (2009). Obesogenic environments - Aspects on measurement and indicators. *Public Health Nutrition*, 12(3), 307-315.

Finster, M.E., Gray, K.A. and Binns, H.J. (2004). Lead levels of edibles grown in contaminated residential soils: A field survey. *Science of the Total Environment,* 320(2-3), 245-257.

Gittelsohn, J. and Sharma, S. (2009). Physical, consumer, and social aspects of measuring the food environment among diverse low-income populations. *American Journal of Preventive Medicine,* 36(4), S161-S165.

Glanz, K. (2009). Measuring food environments: A historical perspective. *American Journal of Preventive Medicine,* 36(4), S93-S98.

Glanz, K., Sallis, J.F., Saelens, B.E. and Frank, L.D. (2007). Nutrition environment measures survey in stores (NEMS-S) - Development and evaluation. *American Journal of Preventive Medicine*, 32(4), 282-289.

Goldberg, M.E. and Gunasti, K. (2007). Creating an Environment in which youths are encouraged to eat a healthier diet. J*ournal of Public Policy & Marketing*, 26(2), 162-181.

Graham, H. and Zidenberg-Cherr, S. (2005). California teachers perceive school gardens as an effective nutritional tool to promote healthful eating habits. *Journal of the American Dietetic Association*, 105(11), 1797-1800.

Hackman, R.M. and Wagner, E.L. (1990). The senior gardening and nutrition project: Development and transport of a dietary behaviour change and health promotion program. *Journal of Nutrition Education*, 22(6), 262-270.

Hamelin, A.M., Mercier, C. and Bedard, A. (2008). Perception of needs and responses in food security: Divergence between households and stakeholders. *Public Health Nutrition*, 11(12), 1389-1396.

Handy, S.L., Boarnet, M.G., Ewing, R. and Killingsworth, R.E. (2002). How the built environment affects physical activity: Views from urban planning. *American Journal of Preventive Medicine*, 23(2, Supplement 1), 64-73.

Hemphill, E., Raine, K., Spence, J.C. and Smoyer-Tomic, K.E. (2008). Exploring obesogenic food environments in Edmonton, Canada: The association between socio-economic factors and fast-food outlet access. *American Journal of Health Promotion,* 22(6), 426-432.

Hoisington, A., Butkus, S.N., Garrett, S. and Beerman, K. (2001). Field gleaning as a tool for addressing food security at the local level: Case study. *Journal of Nutrition Education,* 33(1), 43-48.

Holben, D.H., McClincy, M.C., Holcomb, J.P., Dean, K.L. and Walker, C.E. (2004). Food security status of households in Appalachian Ohio with children in Headstart. *Journal of the American Dietetic Association*, 104(2), 238-241.

Hough, R.L., Breward, N., Young, S.D., Crout, N.M.J., Tye, A.M., Moir, A.M., et al. (2004). Assessing potential risk of heavy metal exposure from consumption of home-produced vegetables by urban populations. *Environmental Health Perspectives,* 112(2), 215-221.

Inglis, V., Ball, K. and Crawford, D. (2005). Why do women of low socio-economic status have poorer dietary behaviours than women of higher socio-economic status? A qualitative exploration. *Appetite,* 45(3), 334-343.

Jackson, R. J. (2003). The impact of the built environment on health: An emerging field. *American Journal of Public Health*, 93(9), 1382-1384.

Jetter, K.M. and Cassady, D.L. (2006). The availability and cost of healthier food alternatives. *American Journal of Preventive Medicine*, 30(1). 38-44.

Kamphuis, C.B.M., Giskes, K., de Bruijn, G-J., Wendel-Vos, W., Burg, J. and van Lenthe, F.J. (2006). Environmental determinants of fruit and vegetable consumption among adults: A systematic review. *British Journal of Nutrition,* 96(4), 620-635.

Kirkpatrick, S., and Tarasuk, V. (2003). The relationship between low income and household food expenditure patterns in Canada. *The Journal of Nutrition,* 6(6), 589-597.

Larsen, K. and Gilliland, J. (2008). Mapping the evolution of 'food deserts' in a Canadian city: Supermarket accessibility in London, Ontario, 1961-2005. *International Journal of Health Geographics*, 7, 16.

Larson, N.I., Story, M.T. and Nelson, M.C. (2009). Neighborhood environments disparities in access to healthy foods in the US. *American Journal of Preventive Medicine*, 36(1), 74-81.

Liese, A.D., Weis, K.E., Pluto, D., Smith, E. and Lawson, A. (2007). Food store types, availability, and cost of foods in a rural environment. *Journal of the American Dietetic Association*, 107(11), 1916-1923.

Lytle, L.A. (2009). Measuring the food environment: State of the science. *American Journal of Preventive Medicine*, 36(4), S134-S144.

McKinnon, R.A., Reedy, J., Morrissette, M.A., Lytle, L.A. and Yaroch, A.L. (2009). Measures of the food environment: A compilation of the literature, 1990-2007. *American Journal of Preventive Medicine,* 36(4), S124-S133.

Mendes, W. (2008). Implementing social and environmental policies in cities: The case of food policy in Vancouver, Canada. *International Journal of Urban and Regional Research*, 32(4), 942-967.

Mendes, W., Balmer, K., Kaethler, T. and Rhoads, A. (2008). Using land inventories to plan for urban agriculture experiences from Portland and Vancouver. *Journal of the American Planning Association*, 74(4), 435-449.

Mojtahedi, M.C., Boblick, P., Rimmer, J.H., Rowland, J.L., Jones, R.A. and Braunschweig, C.L. (2008). Environmental barriers to and availability of healthy foods for people with mobility disabilities living in urban and suburban neighbourhoods. *Archives of Physical Medicine and Rehabilitation*, 89(11), 2174-2179.

Monsivais, P., and Drewnoski, A. (2007). The rising cost of low-energy-density foods. *Journal of the American Dietetic Association*, 107(12), 2071-2076P.

Moore, L.V. and Diez Roux, A.V. (2006) Associations of neighbourhood characteristics with the location and types of food stores. *American Journal of Public Health*, 96(2), 325-331.

Moore, L.V., Diez Roux, A.V., Nettleton, J.A. and Jacobs, Jr., D.R. (2008). Associations of the local food environment with diet quality – A comparison of assessments based on surveys and geographic information systems. *American Journal of Epidemiology,* 167(8), 917-924.

Morland, K., Diez Roux, A.V. and Wing, S. (2006). Supermarkets, other food stores, and obesity: The atherosclerosis risk in communities study. *American Journal of Preventive Medicine,* 30(4), 333–339.

Morland, K., Wing, S. and Roux, A.D. (2002a). The contextual effect of the local food environment on residents' diets: The atherosclerosis risk in communities study. *American Journal of Public Health,* 92(11), 1761-1767.

Morland, K., Wing, S., Roux, A.D. and Poole, C. (2002b). Neighbourhood characteristics associated with the location of food stores and food service places. *American Journal of Preventive Medicine*, 22(1), 23-29.

Moron, C. (2006). Food-based nutrition interventions at community level. *British Journal of Nutrition*, 96(Supplement 1), S20-S22.

Morton, L.W., Bitto, E. A., Oakland, M.J. and Sand, M. (2008). Accessing food resources: Rural and urban patterns of giving and getting food. *Agriculture and Human Values*, 25(1), 107-119.

Ostry A. (2009). School food environments and food security, Provincial Health Services Authority, Vancouver, BC.

PHSA (2007). Perspectives on community based food security projects: discussion paper. Retrieved June 6, 2008 fromwww.phsa.ca/HealthPro/PreventionPromoProtect/default.htm

Papas, M.A., Alberg, A.J., Ewing, R., Helzlsouer, K.J., Gary, T.L. and Klassen, A.C. (2007). The built environment and obesity. *Epidemiologic Reviews,* 29(1), 129-143.

Pearson T., Russell J., Campbell M.J. and Barker M.E. (2005). Do 'food deserts' influence fruit and vegetable consumption? – A cross-sectional study. *Appetite,* 45(2), 195–197.

Pettinger, C., Holdsworth, M. and Gerber, M. (2008). 'All under one roof?' Differences in food availability and shopping patterns in Southern France and Central England. *European Journal of Public Health*, 18(2), 109-114.

Provincial Health Officer's Annual Report. (2005). *Food, health and well-being in British Columbia.* British Columbia Ministry of Health, Office of the Provincial Health Officer.

Sharkey, J.R. (2009). Measuring potential access to food stores and food-service places in rural areas in the US. A*merican Journal of Preventive Medicine*, 36(4), S151-S155.

Sharkey, J.R. and Horel, S. (2008). Neighbourhood socio-economic deprivation and minority composition are associated with better potential spatial access to the ground-truthed food environment in a large rural area. *Journal of Nutrition*, 138(3), 620-627.

Skinner, K., Hanning, R.M. and Tsuji, L.J.S. (2006). Barriers and supports for healthy eating and physical activity for first nation youths in northern Canada. *International Journal of Circumpolar Health,* 65(2), 148-161.

Sloane, D.C., Diamant, A.L., Lewis, L.B., Yancey, A.K., Flynn, G., Nascimento, L.M., et al. (2003). Improving the nutritional resource environment for healthy living through community-based participatory research. *Journal of General Internal Medicine,* 18(7), 568-575.

Smart Growth BC. (2005). *A Citizen's Guide: Protecting Agricultural Land in BC.* Vancouver. http://www.smartgrowth.bc.ca/Portals/0/Downloads/Citizens_Guide_2005.pdf

Smart Growth BC. (2004). T*he State of the Agricultural Land Reserve.* Vancouver. http://www.smartgrowth.bc.ca/Portals/0/Downloads/State_of_the_ALR_Report_final.pdf

Smart Growth BC. (2009). *Creating Healthy Communities. Tools and Actions to Foster Environments for Health Living.* Victoria. http://www.smartgrowth.bc.ca/Portals/0/Downloads/CreatingHealthyCommunitiesGuide.pdf

Smoyer-Tomic, K.E., Spence, J.C. and Amrhein, C. (2006). Food deserts in the prairies? Supermarket accessibility and neighbourhood need in Edmonton, Canada. *Professional Geographer,* 58(3), 307-326.

Smoyer-Tomic, K.E., Spence, J.C., Raine, K.D., Amrhein, C., Cameron, N., Yasenovskiy, V., et al. (2008). The association between neighbourhood socio-economic status and exposure to supermarkets and fast food outlets. *Health & Place,* 14(4), 740-754.

Sobal, J. and Wansink, B. (2007). Kitchenscapes, tablescapes, platescapes, and foodscapes - Influences of microscale built environments on food intake. *Environment and Behaviour,* 39(1), 124-142.

Story, M., Kaphingst, K.M., Robinson-O'Brien, R. and Glanz, K. (2008). Creating healthy food and eating environments: Policy and environmental approaches. *Annual Review of Public Health*, 29, 253-272.

Travers, K.D. (1996). The social organization of nutritional inequities. *Social Science & Medicine*, 43(4), 543-553.

Turrell G., Blakely T., Patterson C. and Oldenburg B. (2004). A multilevel analysis of socio-economic (small area) differences in household food purchasing behaviour. *Journal of Epidemiology & Community Health,* 58(3), 208–215.

Twiss, J., Dickinson, J., Duma, S., Kleinman, T., Paulsen, H. and Rilveria, L. (2003). Community gardens: Lessons learned from California healthy cities and communities. American *Journal of Public Health,* 93(9), 1435-1438.

Vancouver Coastal Health Authority. 2008. Food security and housing: *Preliminary rationale and strategies for the subsidized housing sector, Vancouver.*

Vancouver Coastal Health Authority. 2009. *Food security and housing in Vancouver's Downtown Eastside. Prepared by Christianna Miewald, Vancouver.*

Veugelers, P., Sithole, F., Zhang, S. and Muhajarine, N. (2008). Neighbourhood characteristics in relation to diet, physical activity and overweight of Canadian children. *International Journal of Pediatric Obesity*, 3(3), 152-59.

Vogl, C.R., Axmann, P. and Vogl-Lukasser, B. (2004). Urban organic farming in Austria with the concept of Selbsternte ('self-harvest'): An agronomic and socio-economic analysis. *Renewable Agriculture and Food Systems,* 19(2), 67-79.

Wahlqvist, M.L. (2002). Asian migration to Australia: food and health consequences. *Asia Pacific Journal of Clinical Nutrition,* 11, S562-68.

Wakefield, S., Yeudall, F., Taron, C., Reynolds, J. and Skinner, A. (2007). Growing urban health: Community gardening in South-East Toronto. *Health Promotion International,* 22(2), 92-101.

Wang, M.C., Cubbin, C., Ahn, D. and Winkleby, M.A. (2008). Changes in neighbourhood food store environment, food behaviour and body mass index, 1981-1990. *Public Health Nutrition,* 11(9), 963-70.

Weich, S., Burton, E., Blanchard, M., Prince, M., Sproston, K. and Erens, B. (2001). Measuring the built environment: validity of a site survey instrument for use in urban settings. *Health & Place*, 7(4), 283-92.

Whelan, A., Wrigley, N., Warm, D. and Cannings, E. (2002). Life in a 'food desert'. *Urban Studies,* 39(11), 2083-100.

Winkler, E., Turrell, G. and Patterson, C. (2006). Does living in a disadvantaged area mean fewer opportunities to purchase fresh fruit and vegetables in the area? Findings from the Brisbane food study. *Health & Place,* 12(3), 306-19.

Zenk, S.N., Schulz, A.J., Hollis-Neely, T., Campbell, R.T., Holmes, N., Watkins, G., et al. (2005a). Fruit and vegetable intake in African Americans - Income and store characteristics. *American Journal of Preventive Medicine,* 29(1), 1-9.

Zenk, S.N., Schulz, A.J., Israel, B.A., James, S.A., Bao, S.M. and Wilson, M.L. (2005b). Neighbourhood racial composition, neighbourhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. *American Journal of Public Health,* 95(4), 660-67.

Chapter Seven:
School Food Environments and Food Security

As shown in the previous chapter, the character of the built environment is important in affecting community nutritional health. Policy makers have several resources at their disposal to make improvements. Most notably, altering the built environment requires working with local building codes and zoning by-laws. When considering how to alter the built environment for improved nutrition of children, one of the first steps should be an examination of studies and reports pertaining to the nutritional environments both inside and outside schools. A clear understanding of these environments will help to effect positive change.

A large body of literature on school food environments exists. Much of this literature deals with the infrastructure of food provision within schools and the presence of vending machines, although some studies investigate the impact of school gardens and compost facilities on nutrition. Others consider the proximity of fast food and similar types of outlets and their impact on student nutrition.

Most studies were conducted outside Canada. One BC study, considered here in some detail, was completed in 2005 and systematically describes the nutritional environment inside the public school system. In recent years the BC government, often in conjunction with community groups, has moved aggressively in the area of school food nutrition, establishing a number of innovative programs, which are also described in this chapter.

The first section reviews studies on food security and the built environment outside the school. The second section examines the literature on food security and the built environment within schools, ending with a description of BC's 2005 school nutrition survey. A description of programs established in the BC school system since 2005 appears in the final section.

Food Security and the Built Environment Outside Schools

A few studies identify the relationship between the location of convenience stores and fast food restaurants near schools. One study, conducted in 85 percent of Chicago's kindergartens and primary and secondary schools, demonstrated that fast-food restaurants were clustered in areas within a short walking distance from schools. An estimated three to four times as many restaurants were located within 1.5 km of schools, than if restaurants had been distributed randomly (Austin et al. 2005).

Another study examined the availability of fast food restaurants and convenience stores within walking distance (0.5 miles) to 31,243 US public secondary schools across 50 states (Zenk and Powell 2007). Unlike

the Chicago study, which found that fast food restaurants were clustered around schools in the highest-income neighbourhoods this study found that as neighbourhood income decreased, food outlet clustering around schools increased. This study also demonstrated that schools in African-American areas had fewer retail food outlets within walking distance, than those in other neighbourhoods.

In a qualitative pilot study of four communities in Atlanta, Georgia, spatial analyses indicated that there were more convenience stores near schools than grocery stores, and convenience stores in the higher-income neighborhoods offered more "healthy options" than those in the lower-income neighborhoods. This study was not able to test for statistical significance because of the small sample size (Frank et al. 2007).

A recent study investigated the location of convenience stores, limited-service restaurants, snack stores and liquor stores within a 400 to 800 meter radius around middle and high schools in the US (n=31,622) (Sturm 2008). This study found that schools, with a higher proportion of students eligible for free school meals and from low-income families, had higher likelihood that convenience stores and fast food restaurants would be located nearby.

These studies were methodically rigorous and were conducted with unusually large sample sizes. They reveal that the food environments near middle schools and high schools vary according to the neighbourhood socio-economic status (SES). Most studies (Zenk and Powell 2007; Frank et al., 2007; Sturm, 2008) indicated poorer community nutrition environments near schools located in poorer areas. In the only study conducted of urban/rural differences, schools in rural neighbourhoods were surrounded by far fewer food outlets than schools in urban areas (Sturm, 2008).

These studies contribute to our understanding of the proximity of retail food outlets to schools, in relation to area deprivation. Although they are largely limited to the urban United States they do provide insight into the availability of snacks, sodas and fast food in the immediate vicinity. Availability may negate improvements in the nutritional environment within schools and could also lower the effectiveness of health education in the classroom by setting a visible example that counters educational messages while providing access to "junk" food in the vicinity of the school.

Similar investigations conducted in BC could yield similar findings. It should be noted, however, that one of four studies conducted in the United States, indicated higher levels of exposure to fast food outlets, with poor food choices in middle and higher income neighbourhoods. Thus, it remains to be determined if this might also be the case in BC. Based on American results it is difficult to generalize, which only serves to emphasize the need for BC research on this issue. Improving school nutrition environments will require focusing on the community nutrition environments near schools, and not just on the situation within the schools.

Food Security and the Built Environment Within Schools

Research indicates that the school environment can have a powerful influence on student eating behaviours (Story, 1999; Pilant, 2006). In particular, the type of food offered in school cafeterias, tuck shops and vending machines may be very important in shaping student nutritional habits. When high fat foods and sugary treats are available within the school this influences dietary choices for students during their school day (Hayne, Moran and Ford, 2004). Unhealthy food choices also reduce the availability of nutritious foods during the school day (Veugelers and Fitzgerald, 2005a, b).

The presence of vending machines with unhealthy choices has been shown to reduce fruit intake, as the low-nutrient vending snacks tend to be chosen over healthy fruit-based drinks (French et al., 2003). French et al. (2003) also demonstrated that when students are exposed to less healthful choices at school they do not compensate by choosing more healthful choices when they are away from school.

Kubik et al. (2003) conducted an investigation in 16 schools in an urban US area. He collected dietary information from seventh-grade students using 24-hour dietary recalls. In schools with greater junk food availability in the cafeteria and more snack vending machines, students had lower intakes of fruit and vegetables. There was also a higher consumption of total and saturated fats compared to students with less junk food availability and fewer snack machines.

Researchers in Kentucky found that when elementary school students entered middle school and gained access to school snack bars, they consumed fewer fruits and non-starchy vegetables, less milk and more sweetened beverages and high-fat vegetables than when they were in elementary schools – where they only had the option of a school lunch program (Cullen and Zakeri, 2004). Another Kentucky study of 743 sixth-grade students, aged 11 to 13, in three public middle schools, revealed one-third of the students who purchased the regular school lunch also bought junk food items. This reduced their school lunch servings, lowered intakes of minerals and vitamins and raised intakes of calories and fat (Templeton, Marlette and Panemangalore, 2005).

In Nova Scotia Veugelers and Fitzgerald (2005a) conducted a comprehensive survey of school-based risk factors for overweight and obese children in grade five. They measured height and weight and assessed dietary habits using a food frequency questionnaire. Measurements were taken among 4,298 students from 242 (83.3 percent) of the province's public schools. Compared to children who brought their lunch from home, those who purchased lunches at school were at increased risk of being overweight. This suggests that there is great room for improvement in school nutrition environments. Improving the nutritional quality of school lunches provides an opportunity to reduce the number of overweight and obese students. In a related study examining the influence of the school environment, Veugelers and Fitzgerald (2005b) showed that students participating in integrated school nutrition programs exhibited lower rates of excess weight and obesity, had healthier diets and were more physically active than students from schools without these programs. Nutrition programs involved several factors, including physical education, healthy lunches, health and nutrition education, training of staff on health promotion, parental involvement and the elimination of soft drink sales.

Although most research on the built environment is focused on the impact of changing the infrastructure and food choices offered within different types of school food outlets, a large body of research also exists on the efficacy of school-based educational interventions (mainly in primary schools in the United States). This literature demonstrates some success in increasing fruit intake among children, but little impact on increasing vegetable consumption (Anderson et al., 2005; Nicklas et al., 1998; Perry et al., 1998; Baranowski et al., 2000; Reynolds et al., 2000; Agency for Health and Research Quality, 2001). These studies don't strictly involve alteration of the built environment except for a small sub-set of these studies, which have investigated the educational and nutritional impact of schools with specific spaces for gardens and composting.

In a review of the American reports on the impact of school gardening programs Blair (2009) found that while school gardening has become virtually a national movement, few evaluations of these programs have been conducted. The states of Texas and California have encouraged extensive programming in school-based

gardening. Blair reviewed the literature for both qualitative and quantitative evaluations of these programs. The evaluations all indicated a) primary students gained pleasure from gardening at school, b) gardening promoted teamwork among students and c) interactions between students and the community were improved (Dirks and Orvis, 2005; Klemmer, Waliczek and Zajicek, 2005a, b; Lindberger and Zajicek, 2000; Mabie and Barker, 1996; McAleese and Rankin, 2007; Morris, Neustadter and Zidenberg-Cherr, 2001; Morris and Zidenberg-Cherr, 2002; Smith and Mostenbocker, 2005).

In another, more rigorous quantitative intervention study conducted among 100 sixth grade students (not included in Blair's review), researchers demonstrated increased intake of fruit and vegetables for students involved in active gardening at the school. These researchers also found that levels of vitamin A and C increased significantly in the experimental group of students who planted and harvested a garden at their school, when compared to the control group of similar students in a similar school who did not plant or harvest a garden (McAleese and Rankin, 2007). A similar intervention involving gardening in Minneapolis schools, also with about 100 students, demonstrated significant increases in vegetable and fruit consumption, but only for boys in the experimental group (Lautenschlager and Smith, 2007). These investigations of school gardening, particularly the latter intervention studies, indicate their potential to improve nutritional habits among students.

The 2005 BC Public School Survey

The purpose of the 2005 Public School Survey was to determine the number and types of different food sales outlets, the types of foods offered for sale in all schools and the extent of nutrition policy implementation in British Columbia. The study also directly measured the number and types of snack foods available for sale in each vending machine at each school. This investigation is reviewed here in some detail because it is one of the few rigorous studies of the school nutrition environment conducted in BC.

Based on a thorough examination of documentation and guided by a panel of nutritionists, a method was developed to measure the quantity and type of food offered for sale in vending machines, the type of food for sale in all school food outlets and the extent of nutrition policy development in the schools. The survey response rate was 74 percent. Approximately 60 percent of surveyed schools had a permanent food sales outlet. Snack and beverage vending machines were most common in secondary schools, while tuck shops and food-based fundraisers were more common in elementary schools.

Study authors concluded that "junk" foods were widely available in elementary, middle and secondary schools through a variety of outlets. Although snack machines were virtually absent in elementary schools, tuck shops and school fundraisers sold foods usually found in snack machines, largely cancelling the positive effect of the absence of snack machines in these schools. Approximately 25 percent of schools had a formal group responsible for nutrition and these schools were more likely to have nutrition policies in place (Rideout et al., 2007).

After this 2005 survey, the Ministry of Education and the Ministry of Health introduced the Guidelines for Food and Beverage Sales in BC Schools. These guidelines maximize student access to healthier options and minimize the sale of unhealthy foods and beverages in BC schools. They were developed by a team of BC Community Nutritionists and align with the most current edition of the Canada Food Guide (2007).

The BC government has also developed or supported the development of other resources designed to assist schools and school districts in the creation of healthy food environments. These resources include the Brand Name Food List website, HealthLink BC's Dietitian Services and healthy recipe and fundraising publications. As well, a School Meal and School Nutrition Program Handbook is now in the final stages of development. The Handbook supports school breakfast, lunch, snack and nutrition programs, including programs funded through the Ministry of Education's CommunityLINK initiative.

Government and government-supported programs have assisted schools in creating healthy food environments through several innovative new programs. For example, the School Fruit and Vegetable Nutritional Program, supported by the Ministries of Education, Agriculture and Lands, and Healthy Living and Sport, provide students and staff with a fresh fruit or vegetable snack twice a week, every other week for 14 weeks (www.aitc.ca/bc/snacks/). The fruits and vegetables served in the program are grown in BC, which helps to support farmers and strengthen local food security. As of September 2009, 933 public schools are participating in this program.

Another program, School Community Connections, has provided funding to dozens of schools for kitchen renovations, school/community gardens and greenhouse projects, (www.schoolconnections.ca/). Action Schools! BC is a best practice model designed to assist schools in creating individualized action plans to promote healthy eating and physical activity. Research has shown that the Healthy Eating component is effective at positively impacting elementary student vegetable and fruit consumption. As of May 31, 2009 there were 1644 registered Action Schools, with 558 of those being registered Action Schools! BC Healthy Eating Schools.

Finally, the BC Public Health Association is piloting a Farm to School Salad Bar in approximately two-dozen schools located mainly in the North and the Interior of the province, where access to such foods can be limited. A central focus is to build relationships between schools and local farms. In this pilot program, parents, students and school staff prepare, serve and eat fresh local produce. Children benefit because fresh vegetables and fruit are readily available at school and they learn about the local food system, nutrition and health. www.phabc.org/modules.php?name=Farmtoschool&pa=showpage&pid=4).

Conclusions

This chapter offers a perspective on how nutritional environments in and around schools impact student health and education. The school food environment is not just about cafeterias, vending machines and fundraisers inside our school buildings. It is also about the number of fast food outlets and convenience stores and their proximity to schools and about policies controlling the types of food permitted within the school built environment. Research shows poor food choices translate into poor dietary and nutritional health among students and that when poor food choices are available within a school, students tend to choose them. It also indicates that community nutrition environments in the vicinity of schools exert a strong influence on student nutritional habits.

While there is research in the United States and in other regions of Canada on student nutritional habits, there is a need to conduct this type of research in BC.

The built environment improvements that research supports are: establishing parent and staff nutrition committees in schools, ensuring that fundraisers use healthy food, reducing or eliminating vending machines

that offer unhealthy choices and ensuring cafeterias and tuck shops offer healthy food choices. The latter three are all now required in BC. Since the BC government prohibited the sale of all junk food in schools several other innovative programs have also been adopted. These programs hold promise, but will need to be evaluated for effectiveness.

References

Agency for Healthcare Research and Quality (2001). "Efficacy of interventions to modify dietary behavior related to cancer risk." [Online] Available at http://www.ahrq.gov/clinic/epcsums/dietsumm.htm

Anderson, A.S., Porteous, L.E.G., Foster, E., Higgins, C., Stead, M., Hetherington, M., et al. (2005). "The impact of a school-based nutrition education intervention on dietary intake and cognitive and attitudinal variables relating to fruits and vegetables." Public Health Nutrition 8(6): 650-656.

Austin, S.B., Melly, S.J., Sanchez, B.N., Patel, A., Buka, S. and Gortmaker, S. L. (2005). "Clustering of fast-food restaurants around schools: A novel application of spatial statistics to the study of food environments." Am J Public Health 95(9): 1575-81.

Baranowski, T., Davis, M., Resnicow, K., Baranowski, J., Doyle, C., Lin, L.S., et al. (2000). "Gimme 5 fruit, juice, and vegetables for fun and health: outcome evaluation." Health Education & Behavior 27: 96-111.

Black, M. (2003). "Micronutrient deficiencies and cognitive functioning." J Nutr 133(11, Suppl. 2): 3927S-31S.

Blair, D. (2009). "The child in the garden: An evaluative review of the benefits of school gardening." The Journal of Environmental Education 40(2): 15-38.

Cullen, K.W., and Zakeri, I. (2004). "Fruits, vegetables, milk, and sweetened beverages consumption and access to a la carte/snack bar meals at school." Am J Public Health 94(3): 463-7.

Delva, J., O'Malley, P.M. and Johnston, L.D. (2007). "Availability of more-healthy and less-healthy food choices in American schools: a national study of grade, racial/ethnic, and socio-economic differences." Am J Prev Med 33(4, Suppl): S226-39.

Dirks, A.E. and Orvis, K. (2005). "An evaluation of the junior master gardener program in third grade classrooms." Hort Technology 15: 443-447.

Frank, L., Glanz, K., McCarron, M., Sallis, J., Saelens, B. and Chapman, J. (2006). "The spatial distribution of food outlet type and quality around schools in differing built environment and demographic contexts." The Berkeley Planning Journal 19: 31-47.

French, S.A., Story, M., Fulkerson, L.A. and Gerlach, A.F. (2003). "Food environment in secondary schools: a la carte, vending machines, and food policies and practices." Am J Public Health 93(7): 1161-7.

Hayne, C.L., Moran, P.A., and Ford, M.M. (2004). "Regulating environments to reduce obesity." J Public Health Policy 25(3-4): 391-407.

Health Canada (1997). Food for Thought: Schools and Nutrition. Ottawa: Health Canada.

Klemmer, C.D., Waliczek, T.M. and Zajicek, J.M. (2005a). "Development of a science achievement evaluation instrument for a school gardening program." Hort Technology 15: 433-438.

Klemmer, C.D., Waliczek, T.M. and Zajicek, J.M. (2005b). "The effects of a school gardening program on the science achievement of elementary students." Hort Technology 15: 448-452.

Kubik, M.Y., Lytle, L.A., Hannan, P.J., Perry, C.L. and M. Story, M. (2003). "The association of the school food environment with dietary behaviors of young adolescents." Am J Public Health 93(7): 1168-73.

Lautenschlager, L., and Smith, C. (2007). "Understanding gardening and dietary habits among youth garden program participants using the Theory of Planned Behavior." Appetite In Press.

Lindberger, S.E., and Zajicek, J.M. (2000). "School gardens: Can a hands-on teaching tool affect students' attitudes and behaviors regarding fruits and vegetables?" Hort Technology 10: 593-597.

Mabie, R. and Baker, M. (1996). "The influence of experiential instruction on urban elementary students' knowledge of the food and fiber system." Journal of Extension 34(6): 1-4.

McAleese, J.D. and Rankin, L. L. (2007). "Garden based nutrition education affects fruit and vegetable consumption in sixth grade adolescents." J Am Diet Assoc 107(4): 662-665.

Morris, J.L. and Zidenberg-Cherr, S. (2000). "Garden-enhanced nutrition curriculum improves fourth-grade school children's knowledge of nutrition and preferences for some vegetables." J Am Diet Assoc 102(1): 91-93.

Morris, J.L., Neustadter, A., and Zidenberg-Cherr, S. (2001). "First-grade gardeners more likely to taste vegetables." California Agriculture 55(1): 43-46.

Morris, J.L., and Zidenberg-Cherr, S. (2002). "Garden-enhanced nutrition curriculum improves fourth-grade school children's knowledge of nutrition and preferences for some vegetables." Journal of the American Dietetic Association 102(1): 91-93.

Nicklas, T.A., Johnson, C.C., Myers, L., Farris, R.P., and Cunningham, A. (1998) "Outcomes of a high school program to increase fruit and vegetable consumption: Gimme 5 – a fresh nutrition concept for students." Journal of Public Health 68: 248-253.

Perry, C.L., Bishop, D., Taylor, G., Murray, D., Mays, R.W., Dudovitz, B. S., et al. (1998) "Changing fruit and vegetable consumption among children: The 5 A Day Power Plus programme in St Paul, Minnesota." American Journal of Public Health 88: 603-609.

Pilant, V.B. (2006). "Position of the American Dietetic Association: local support for nutrition integrity in schools." J Am Diet Assoc 106(1): 122-33.

Reynolds, K.D., Franklin, F.A., Binkley, D., Raczynski, J.M., Harrington, K.F., Kirk, K.A., et al. (2000) "Increasing the fruit and vegetable consumption of fourth-graders: Results from the High 5 project." Preventive Medicine 4: 309-319.

Rideout, K., Martin, C., Levy-Milne, R. and Ostry, A. (2007) "Food Sales and Nutrition Policies in British Columbia Schools". Can J of Public Health 98 (5).

Smith, L.L., and Mostenbocker, C.E. (2005). "Impacts of hands-on science through school gardening in Louisiana public elementary schools." Hort Technology 15: 439-443.

Story, M. (1999). "School-based approaches for preventing and treating obesity." Int J Obes Relat Metab Disord 23 Suppl 2: S43-51.

Story, M., Kaphingst, K.M., Robinson-O'Brien, R. and Glanz, K. (2006). "The role of schools in obesity prevention." Future Child 16(1): 109-42.

Sturm, R. (2008). "Disparities in the food environment surrounding US middle and high schools." Public Health 122(7): 681-90

Templeton, S.B., Marlette, M.A. and Panemangalore, M. (2005). "Competitive foods increase the intake of energy and decrease the intake of certain nutrients by adolescents consuming school lunch." J Am Diet Assoc 105(2): 215-20.

Veugelers, P. and Fitzgerald, A. (2005a). "Prevalence of and risk factors for childhood overweight and obesity." CMAJ 173: 607-13.

Veugelers, P. and Fitzgerald, A. (2005b). "Effectiveness of School Programs in Preventing Childhood Obesity." Am J Public Health 95: 432-435.

Zenk, S. and Powell, L. (2007). "US secondary schools and food outlets." Health and Place In Press.