

# Climate Change

## *Projections and Implications for Edmonton*

By: Dr. Debra J. Davidson

### **Biography**

Debra Davidson is Associate Professor of Environmental Sociology with a joint appointment in the Departments of Rural Economy and Renewable Resources at the University of Alberta. Her primary areas of teaching and research include Natural resource politics and governance; social dimensions of global environmental change; environmental risk; and rural sociology. In recent years she has been focusing on social responses to climate change, particularly community-level vulnerability and adaptation. Recent articles are published in several journals, including *Sociological Inquiry*; *Canadian Review of Sociology*, and *Organization and Environment*. She is also co-editor of *Consuming Sustainability: Critical Social Perspectives on Ecological Change*, Fernwood Press, 2005.

### **Introduction**

This report is designed to inform future planning for the City of Edmonton in the area of climate change mitigation and adaptation, a priority area identified for The Way We Green planning initiative, with particular emphasis on describing the likely implications of climate change for our social and natural systems. Mitigating climate change is a responsibility for all levels of government; however, in North American municipalities have been leading the way. While jurisdictional and fiscal constraints are realities for cities and towns, there are nonetheless several steps that can be taken that have the potential for reducing greenhouse gas emissions that are not only cost-effective, but may offer cost savings. Adaptation to climate change is an absolute necessity, one that, unfortunately has not received due attention to date. Here as well, there are many policy options available to municipalities that can enhance the adaptive capacity of their communities. Policies that are put in place today in the areas of climate change adaptation and mitigation have several spin-off benefits, including future cost avoidance, enhancing community resilience to the multiple sources of uncertainty associated with our complex 21<sup>st</sup> Century social systems, improvements in quality of life, and efficient long-term sustainability planning. Various policy options will be explored at the end of this report, but first a brief summary of the scientific evidence for climate change will be presented, along with its implications for the Edmonton region.

### **A Brief Summary of the Scientific Evidence**

According to the latest Assessment Report produced by the Intergovernmental Panel for Climate Change (IPCC) published in 2007, the global average temperature has increased 0.74°C over the past century, and the rate of change appears to be increasing: eleven of the twelve years leading up to that report's publication (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The authors conclude that

“average Northern Hemisphere temperatures during the second half of the 20th century were *very likely* higher than during any other 50-year period in the last 500 years,” (see Luterbacher et al. 2004) and furthermore, on the basis of recent paleo-climatic research (Mann et al. 1999), is “*likely* the highest in at least the past 1300 years” (IPCC 2007:30, emphasis in original). Predicted land-based impacts of such increases in global average temperature are also being observed. Satellite data since 1979 show that annual average Arctic sea ice extent has shrunk by 3.7% per decade (NASA 2010). As well, global average sea level has been observed to have increased 1.8mm/year between 1961 and 2003, and this rate was 2.8 mm/year between 1993 and 2003 (Bindoff et al. 2007). Snow cover is also on the decrease. Snow cover in the mountainous regions of western North America has declined by 75% since 1950 (Mote et al 2005), due largely to earlier melt periods (Stone et al. 2002). These changes are captured below in Figure 1.

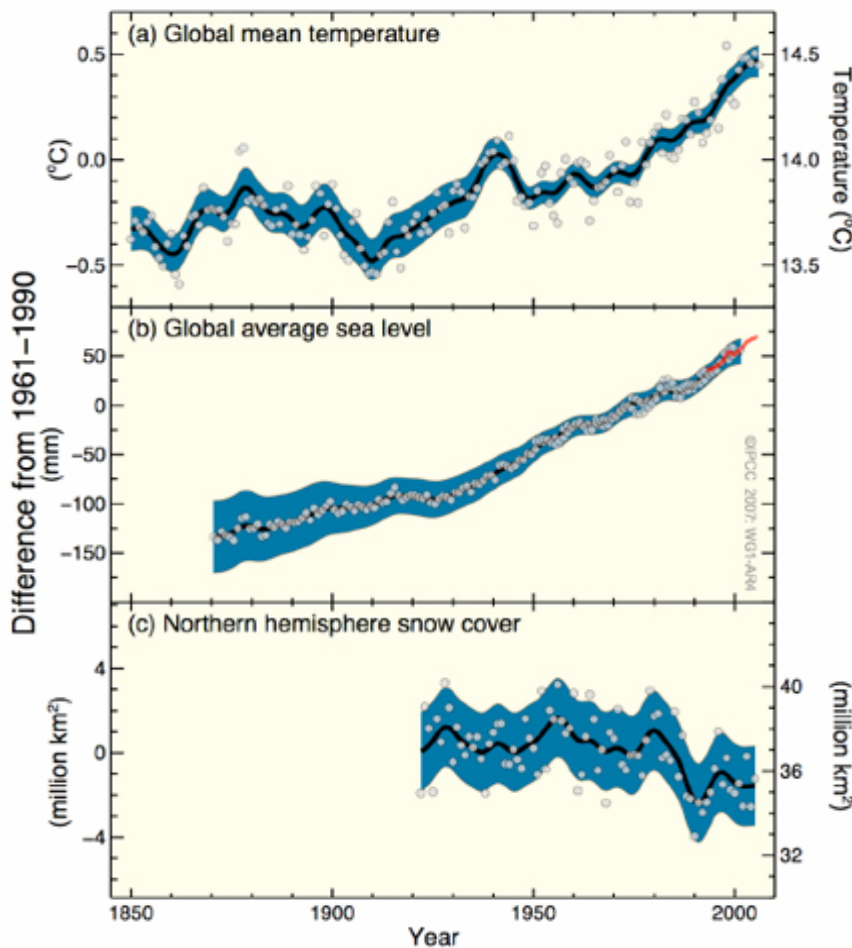


Figure 1. Historic change in average global temperature, seal level and snow cover. Source: IPCC. 2007. Synthesis Report.

### *Association with human activities*

The climate system is characterized by continuous change, however the global warming observed over the past 50 years is unprecedented in at least the past 1,300 years (Osborn and Briffa 2006). Global warming is caused by greenhouse gasses (GHGs). These gasses can be produced by both

natural and human sources, but the notable *increase* in their concentration over the past century is attributed directly to human activities. Industrial activities over the past two centuries have contributed GHGs to the atmosphere, but these increases are particularly notable over the past 40-50 years. The latest IPCC Report (2007) notes an increase of 70% in all GHGs (80% increase in CO<sub>2</sub>) from human activities between 1970 and 2004, with the highest rate of increase between 1995 and 2004 (Figure 2). As a result, concentrations of CO<sub>2</sub>, the most prevalent of GHGs, have increased from a pre-industrial average of 280ppm to 379ppm as of 2005.

The best way to test the relative significance of natural versus human sources of GHGs is through comparison of observed changes in temperatures with computer models that forecast changes in temperatures under two different scenarios, one including human activities and one without. The IPCC did just this, and the results clearly support the conclusion that observed increases in temperature are attributed to human activities. There are simply no natural sources of GHGs that have occurred over the past 100 years that can be attributed to this increase (IPCC 2007a).

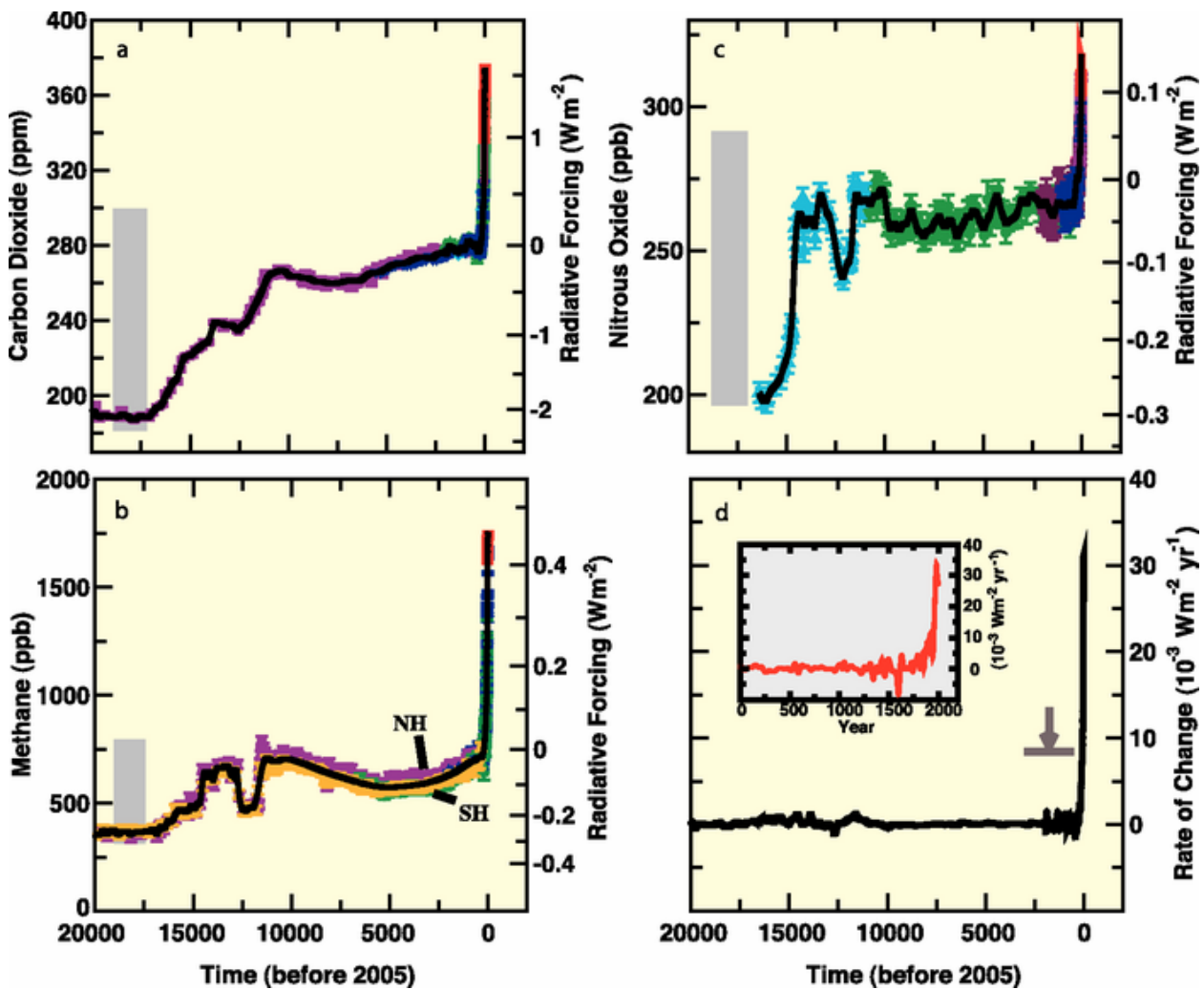


Figure 2. Greenhouse gasses associated with human activities. Source: IPCC 2007a, Figure TS.1

### *Changes forecast for the Edmonton region*

Many Albertans associate climate change with longer summers and warmer winters, and who could complain about this? Indeed, such trends are already evident. In fact, anticipated temperature increases in all models forecast more extreme temperature increases at higher latitudes and continental interiors, both of which describe Alberta. Because climate science tends to be conducted at the global scale, however, our ability to interpret specific local impacts on the basis of global climate scenarios with any detail is somewhat limited. Fortunately, researchers working with the Prairie Adaptation Research Collaborative recently undertook to “downscale” global models to the western prairie region and produced a number of reports, one of which pertains specifically to Alberta (Barrow and Yu 2005). According to Barrow and Yu, global circulation models provide a range in forecasted temperature increases for Edmonton of 2-4°C by the 2020s, 4-7°C by the 2050s, and 5-11°C by the 2080s (Barrow and Yu, Figure 27, p. 49, See Figure 3). Most scenarios indicate that increases in minimum annual temperatures will be larger than increases in maximum temperatures. In other words, we are likely to experience the greatest changes during the Winter and Spring months, rather than Summer. There are some potential benefits of such changes, including a longer growing season (we may experience up to 20% more days per year above 5°C by the 2020s, 50% by the 2050s), reduced heating costs, and reduced number of extreme cold days per year on average.

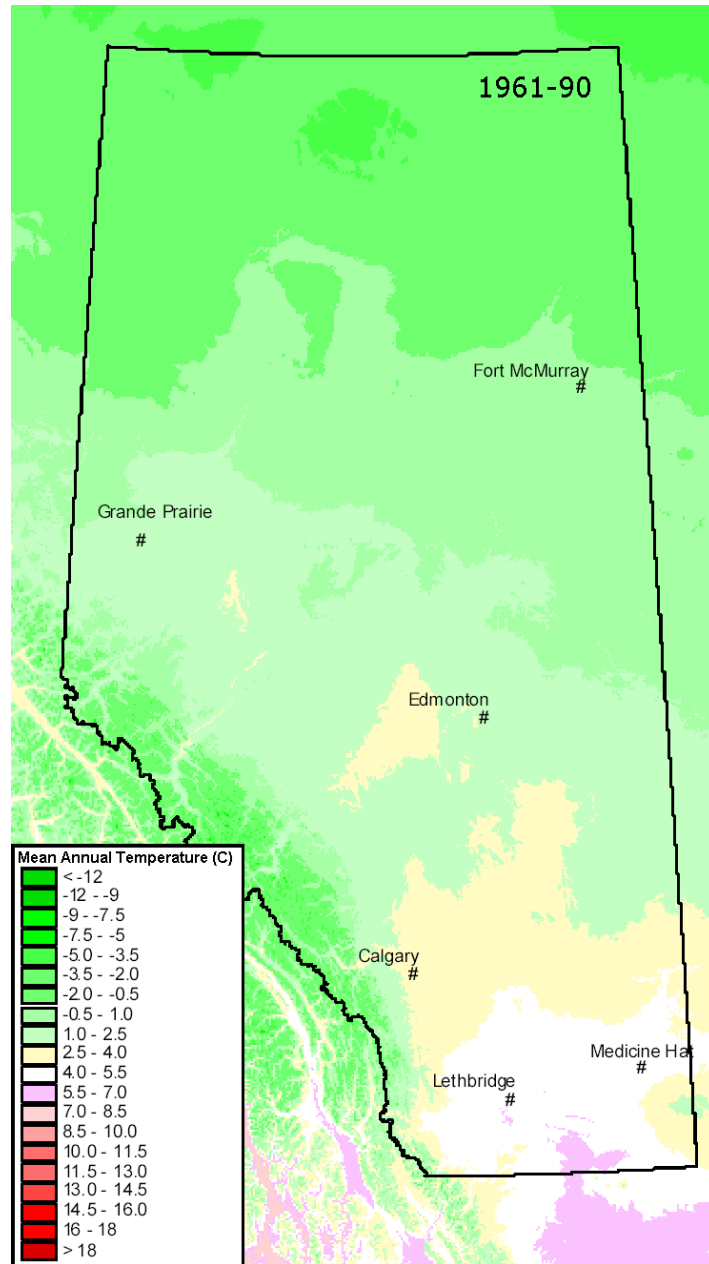


Figure 3a. Mean annual temperature (C) in Alberta for the baseline period, 1961-90, as derived from a median climate change scenario (HadCM3 B2(b)). Source: Barrow and Yu, 2005.

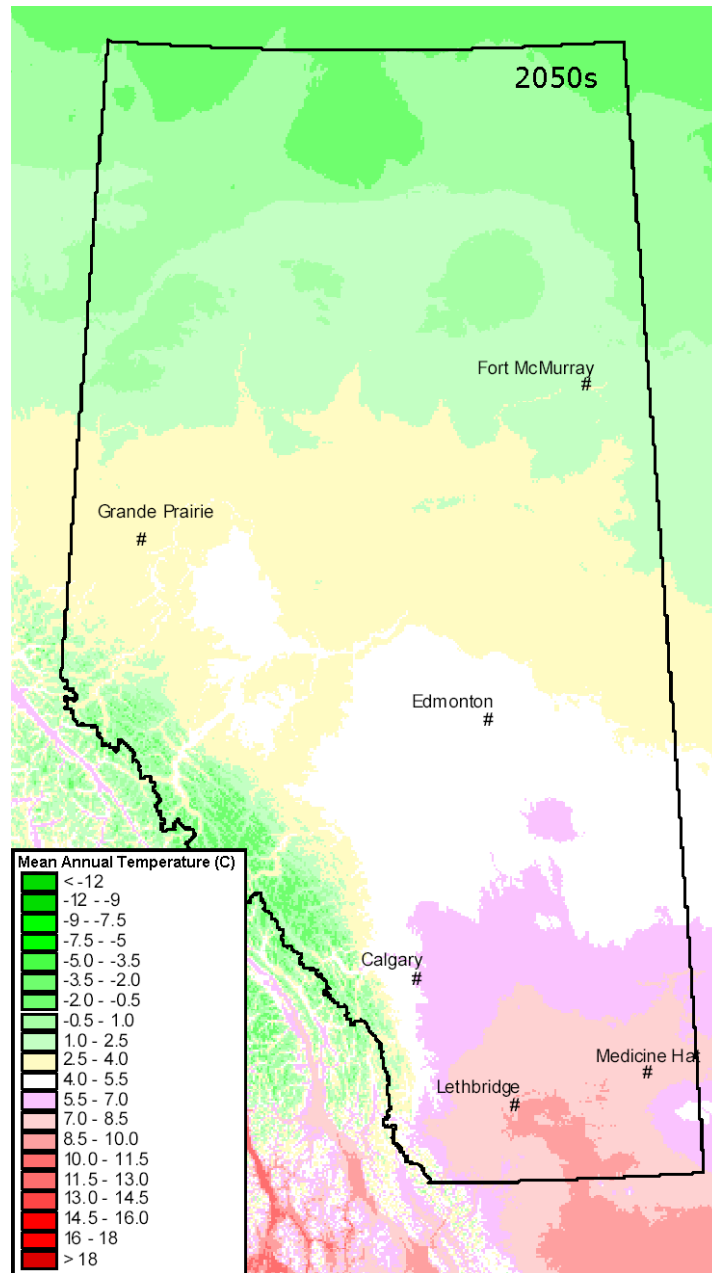


Figure 3b. Mean annual temperature (C) in Alberta for the 2050s as derived from a median climate change scenario (HadCM3 B2(b)). Source: Barrow and Yu 2005.

There are other consequences of warmer temperatures as well however, and not all of them positive. For starters, as stated by some of Canada's own climate scientists, the future ecosystems of Alberta could be "unprecedented" (Weber et al. 2008). Northward migration of vegetation zones, and the animals they support, will occur when ecological corridors allow; when those corridors do not exist species will be threatened. This will be particularly the case for our aquatic species, and the number of migratory fowl in Alberta will decline with expected losses in our wetlands (ibid.). Warmer temperatures also enhance the production of several air

pollutants (Last, Troughton and Pengelli 1998), and the incidence of food-borne disease outbreaks (Kovatz et al. 2004).

The key area of interest for Alberta pertains to our water. Warmer average temperatures are forecast to translate into several changes to our hydrological systems. Increased precipitation is expected for Edmonton of 5% by the 2050s, and 9% by the 2080s, with some models forecasting an increase of up to 31% by the 2080s (Barrow and Yu 2005). The greatest increases will occur in the Summer. However, because of the increase in temperatures and consequently higher rates of evaporation, all models forecast an overall *decrease* in soil moisture, represented (confusingly) by an *increase* in the Annual Moisture Index. Edmonton's Annual Moisture Index is expected to increase 20% by the 2020s, 40% by the 2050s, and 50% by the 2080s. Canada's Prairies are already defined as dry-land, which means that periodic water deficits are a regular feature of our climate, so further decreases in soil moisture are of particular concern. Edmonton's ecosystem is characterized as Parkland, sitting right on the transition between the prairies to the south and the boreal forest to the North, so water deficits are not expected to be quite as severe here as in more southern regions, but they will nonetheless pose significant challenges in the years ahead. This is particularly the case if predicted increases in Alberta's population come to pass (projections range from 3.9 to 4.5 million by 2030, according to Statistics Canada). Other changes to our water supplies include earlier spring run-off, smaller snow pack (which is where we get most of our water), melting glaciers, and more precipitation in the form of rain rather than snow (Weber et al. 2008). Evaluation of stream-flow patterns indicate we have already been experiencing decreases in annual flows in the North Saskatchewan River here in Edmonton over the past 100 years (Weber et al. 2008). Lower stream-flow has implications not just for water quantity, but for water quality as well, by reducing the ability of our waterways to dilute pollutants.

As is true for climate change in general, climate change in the Edmonton area is at least as much about abrupt and unexpected events—climate *variability*—as it is about long term average changes. Climate variability refers to departures from average conditions. If there is one single forecast that is consistent across all scenarios, and one that we should be paying the most attention to, it is this: increases in average global temperatures translate into increased turbulence and unpredictability in our weather systems; in other words, a greater number of days that depart from the average. In Edmonton, there are several anticipated events that we should be aware of. The good news is Alberta has an historically variable climate, so to a certain extent we Albertans have become accustomed to rapid shifts in temperatures and weather patterns. The bad news is such events will happen more frequently, be more intense, and more costly (Lemmen et al. 2008).

The most significant events of concern are extreme droughts and flooding (Lemmen et al. 2008; Weber et al. 2008). Social systems that are reliant on rivers (as Calgary and Edmonton are) or surface water for supply tend to be more susceptible to drought than those reliant on groundwater (Schwarz and Dillard 1990; O'Connor et al. 1999). Droughts have clear implications for water supply, but they also increase the chances of fires, contribute to increased concentration of pollution and pathogens in water bodies (Lincoln 2005), and contribute to air pollution by increasing the amount of airborne particulates (Prospero 1999). Flooding is likely to

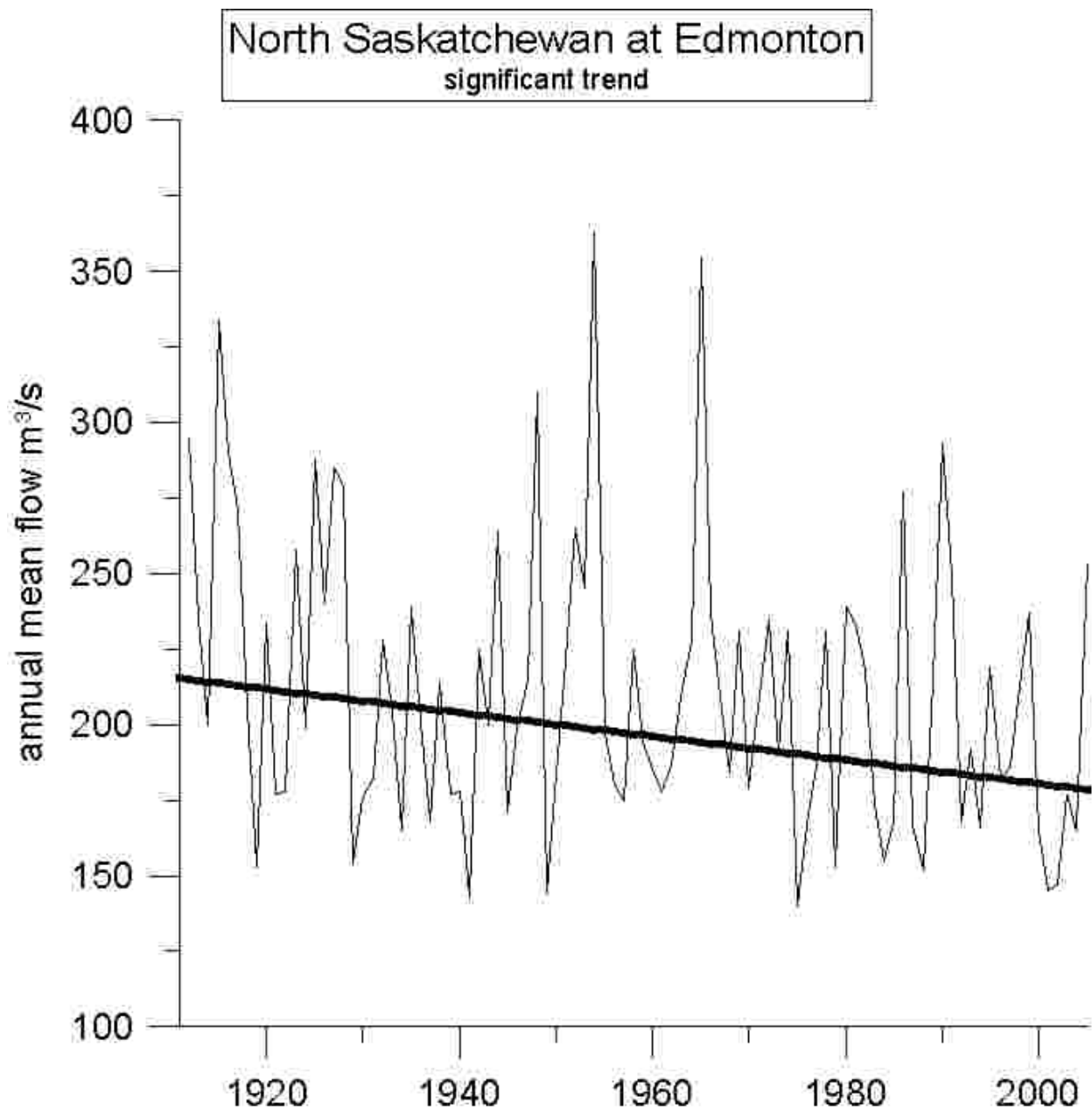


Figure 4. Historic Change in Annual Mean Flows in the North Saskatchewan. Source, Weber et al. 2008.

increase due to more rapid snow melt periods, an increase in the number and intensity of rainfall events. Floods pose direct risks to infrastructure and human health and safety. Much of the damage from flooding emerges after the event itself, in the form of water quality effects: incidences of molds and water-borne diseases explode, particularly in those regions dependent upon open water reservoirs and wells (Epstein and Mills 2005). Drought also enhances the



probability of flooding, since drought conditions cause declines in soil and vegetation cover, which in turn reduce the land's water absorption capacity.

Increases in the number and intensity of heat waves, extreme storm events such as hail storms and tornadoes, and fires are also in Edmonton's forecast. The implications of heat waves will be particularly severe for cities due to the "heat island effect" (Koppe et al. 2004) that characterizes densely built neighbourhoods with limited green space, because concrete absorbs a greater amount of heat. High density residences that lack air-conditioning are of particular concern.

While we have increased our capacity in the developed world for minimizing casualties associated with extreme events (Perrow 2007), extreme storms and fires are a concern for cities like Edmonton primarily due to the concentration of economic infrastructure. In Alberta, the frequency of heavy rainfall events has been increasing since the 1960s (Lawford et al. 1995). The financial costs of such storms have surmounted exponentially in recent years (Perrow 2007). Hailstorms are frequent in Alberta (Charlton et al. 1995), and the number of hail days per year has risen rapidly since the early 1980s (Etkin and Brun 1999). Since the frequency of tornadoes in the western prairies is greater in warmer springs and summers (Etkin 1995), a warming climate could bring an increase in tornado activity in the Prairie Provinces as well (White and Etkin 1997).

Disease outbreaks are also a concern. Much as we complain about our cold winters, they do have one very beneficial effect: they kill off many climate-sensitive pests and diseases that affect our land-based activities, especially agriculture and forestry, and many human disease vectors as well, including in particular hantaviruses and West Nile virus, as well as western equine encephalitis, rabies, influenza, brucellosis, tuberculosis and plague (Charron et al. 2003). With warmer winters expected, we will no longer have this advantage. Individuals who already have compromised immune systems face the greatest risks, including children and the elderly (Davidson et al. 2008).

## **How Vulnerable is the City of Edmonton?**

Cataloguing the expected impacts of climate change to weather and ecosystems describes only one determining factor in the vulnerability of a given social system. These impacts describe what we expect a given system to be *exposed* to, but vulnerability is also determined by the *resilience* of that social system. In other words, how sensitive is the City of Edmonton to anticipated climate change impacts, and what is the potential for adaptation? To address these questions, the following sections translate the direct impacts described above into their likely indirect socio-economic impacts. These are sub-divided into material/infrastructural impacts, and socio-economic impacts.

### *Material/infrastructural impacts*

One of our more significant areas of vulnerability pertains to transportation infrastructure. Greater temperature variability increases the incidences of structural failure in road surfaces, and extreme events also pose the potential for immediate damage to road and rail corridors into and out of the City, which translates into repair costs but also may pose immediate hazard risks

during evacuation events. A proportion of Edmonton's building stock may be also vulnerable to extreme weather events. While a comprehensive assessment of the City's buildings is not available, one indication of building vulnerability is the average age of our residential infrastructure. According to the last Census (2006), over 70% of our housing stock was built prior to 1986. Several neighbourhoods are also categorized as flood-prone.

Major services, including in particular water and electricity are also potentially vulnerable. Sufficient water drainage will be essential in the event of flooding, and current water treatment and storage capacity may not be adequate for enduring a long-term drought. The City should anticipate changes in energy demands as a result of climate change. According to Weber Davidson and Sauchyn (2008) a decline in natural gas demand can be expected due to warmer and shorter winters by up to 4.1% by the 2050s. Electricity demand will increase by up to 3.7%, however, due to increasing air conditioning needs in the Summer months. While we have reliable electricity supplies in Edmonton, the degree of redundancy in our electricity grid should be evaluated. Highly concentrated electricity delivery systems are especially vulnerable, since a failure in one area of the system has the potential for inducing system failure. This is exactly what occurred in the north-east in 2003, when overgrown trees ultimately caused a power failure affecting 55 million people in Canada and the U.S. combined.

The importance of our green spaces in adapting to climate change should not be under-estimated, and hence neither should their vulnerability. Green spaces keep cities cooler, keep our air cleaner, absorb soil moisture during rain events, provide critical habitat for species that will be (already are) under stress, and are an important source of reprieve for city residents. At the moment, air quality in Calgary and Edmonton is as good as, or better than, that of any other Canadian city (<http://www.casadata.org/comparison/index.asp>), although this ranking may change in the future under expected growth conditions and temperature increases.

### *Socio-economic impacts*

Weber, Davidson and Sauchyn (2008) conducted a scenario analysis of expected changes in employment on the basis of various climate models. Forecasts suggest several economic sectors may experience modest declines in employment, while agriculture may experience an increase, amounting to an insignificant net change in overall employment for the Province as a whole. Considering agricultural sector jobs are not well-represented in Edmonton, however, the City may face a modest net reduction in employment in the energy, manufacturing, and public sectors over the next 70 years, but it is possible these jobs could be replaced in emerging green technology sectors.

One of the most immediate impacts to quality of life in Edmonton will be due to overall increases in the cost of living as a result of several factors, including likely increases in energy costs due to peak oil and anticipated carbon taxes, increasing costs of food at least intermittently in response to crop failures, and increases in the costs of home insurance. This means, all else being equal, a higher number of families that lack the ability to stay out of poverty, with clear implications for regional social services, especially in the areas of housing and food provision. As of the 2006 Census, 13.4% of Edmonton families were living in poverty, based on after tax income. The City's ability to meet the needs of these families is strained under current conditions, with over

2,800 reported homeless people in the City in 2006, an increase of 19% over the course of two years.<sup>1</sup>

The stress of extreme events and financial strain has both economic and personal health implications. These will be felt broadly, albeit differentially, depending on the social and economic resources available to particular social groups (Nagel Dietz and Broadbent 2009). There are several sub-populations in Edmonton that may lack sufficient resources to ensure such strains (see Davidson et al. 2008 for discussion), including recent immigrants (29,555 residents who immigrated since 2001 as of 2006 Census), lone parent families (18% of families were headed by single parent in 2006), Aboriginal peoples (38,170 as of the 2006 Census), and the unemployed (3.9% as of the 2006 Census), in addition to the families living in poverty already mentioned.

An additional source of strain may manifest in the form of in-migration of environmental refugees from other parts of the globe, and from Canada's own over-stressed economic regions. With an increase in population of 9.6% between 2001 and 2006 (2006 Census), rapid population growth is already a potential strain on services. According to the same census, 18% of the Edmonton population moved to Edmonton within the previous five years. This represents a high proportion of our community who are less likely to have well-developed social support networks that can be an important resource for coping with crises and adaptation. Many of these conditions—growing prominence of impoverishment, economic inequity, psycho-social stress, and the rapid influx of new residents have the potential to culminate into increasing social conflict (Nagel Dietz and Broadbent 2009).

The health of Edmontonians, and our health care system, rate reasonably positively according to national and global standards according to the Canadian Community and Health Survey (conducted by Statistics Canada in 2003; see also Weber et al. 2008), so this is not expected to be a critical area of vulnerability. A key area of concern will be heat stress, in response to the heat island effect in our inner city neighbourhoods. The density of our City is relatively modest (1,067persons/km<sup>2</sup> in 2006) in comparison to other urban centres, but we do nonetheless have several neighbourhoods in the city core that are susceptible to the heat island effect. Furthermore, because of Edmonton's historically cooler climate, our population is particularly vulnerable to heat waves simply because we are not accustomed to them, and many residences do not have air conditioning. Consequently regions such as ours are likely to experience higher levels of morbidity and mortality from extreme heat events (McGeehin and Mirabelli 2001; Keatinge and Donaldson 2004).

Fortunately, the prevailing winds and geomorphology in Alberta hinder the accumulation of air pollution (Manitoba Conservation, 2002), and thus Alberta cities have good air quality over 90% of the time (CASA, 2006). Declines in opportunities for certain outdoor recreational pursuits (e.g. skiing; water sports) will have a negative impact on the health and quality of life for many Albertans.

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<sup>1</sup> Citizens for Public Justice. 2008. "Poverty in Canada." Accessed at <http://www.cpj.ca/en/content/poverty-canada>, May 11, 2010.

### *Adaptive Capacity*

A comprehensive analysis of adaptive capacity for the City of Edmonton is urgently needed, but there are some indications that our City also may have several sources of adaptive capacity. We have a relatively well-educated community with 20% of the population 15 yrs and over holding a university degree. We also are home to a number of prestigious post-secondary research institutions, particularly the University of Alberta, and Alberta Innovates (formerly the Alberta Research Council). We also have world-class medical and health care facilities. As well, according to a recent survey (Davidson et al. 2008) Albertans expressed high levels of commitment to their community, indicating the potential for participatory engagement and support for planning initiatives. 77% of respondents indicated they were either 'likely' or 'very likely' to remain in their current community should a weather or economic crisis arise.

## **Policy Responses for Increasing Resilience**

In a representative democracy, the first consideration of any elected official when considering new policy initiatives is the potential for support by the electorate. Risk awareness/concern: Alberta survey data. In one recent random survey of 600 Alberta households, respondents indicated high levels of awareness and concern regarding environmental issues, however global warming and climate change was not ranked very high relative to several other environmental issues (Plotnikoff et al. 2004). In a provincial-level survey conducted in 2007, 95% of respondents indicated that they believe our climate is changing (Davidson et al. 2008). A much smaller proportion of respondents expressed awareness that climate change will have a personal impact, however, and research shows that most people are far more willing to support policies if they perceive those policies to be addressing social problems that are personally relevant. Just 65% of Albertans 'agreed' or 'strongly agreed' with the statement that climate change will have a significant impact on them or their family. Furthermore, a small but not insignificant proportion of respondents either do not believe the climate is change at all (5%) or do not believe climate change is caused by human activities (78% of those who indicated they believed the climate is changing). In combination this survey data suggests that there are a large proportion of residents who will likely be supportive of climate change policies that may have implications for their behaviours or their pocketbooks, but there is also a significant minority who will likely resist such actions. Men over the age of 45 were disproportionately represented in this group (Davidson et al. 2008).

### *Climate Change Policies Currently in Place*

Edmonton responded relatively early and pro-actively to climate change concerns with the establishment of the CO2RE program, which set the goal of 20% reduction in greenhouse gas emissions compared to 1990 levels by 2020. The program relies primarily on energy upgrades to municipal facilities and encouragement for voluntary behavioural change targeted at the industrial and residential sectors, including financial incentives for building upgrades (although most of these programs were provincial or federal). Local motion was developed more recently, a program also based on education and encouragement of voluntary behavior change, with a more inclusive, neighbourhood level implementation plan. Edmonton has also been investing heavily in the expansion of its light rail transit system.

Based on an internal document compiled by the Office of Environment on 5 May, 2010, the City has made strong inroads in those areas over which the City has immediate jurisdiction, including City buildings and transport fleet, street lighting, and a waste management system that is among the most progressive in the world.

Overall, the City appears to have been successful at implementing several “low-hanging fruit” mitigation policies. The City may achieve greater gains by re-focusing certain efforts, however, and will also need to engage in the more substantive policy changes in the areas of zoning and energy supply management. There appears to have been an over-emphasis on transportation in City investments to date, and on particularly expensive transit options as well (the LRT). While LRT systems are attractive, and have the highest energy efficiency per distance traveled, municipalities facing fiscal constraints may make greater gains by investing in upgrading bus fleets, and increasing the frequency and expanding the routing of bus lines. Other changes in transportation, such as discouraging private automobile traffic, and improving traffic flow are also areas in which substantial gains can be made.

Ultimately, transportation is not the most significant source of greenhouse gasses, and at any rate, in a cold climate, in a Western cultural system in which private automobiles play a central role, there are certain limits to the gains that can be made by focusing on transportation. Buildings are by far the biggest source of greenhouse gasses, and also the place in which the greatest gains can be made. The City has a relatively old housing stock made up of a high proportion of homes that are poorly insulated. As well, few home owners have been able to capture the gains offered by recent technological advances that have significantly improved the energy efficiency of large appliances. The incorporation of some relatively simple and cost effective efficiency improvements in public and business buildings may also offer an effective route for greenhouse gas reduction.

While reducing demand for energy among consumers will be an important component of any mitigation plan, meeting the targets set in the CO2RE plan, much less the much more drastic cuts of between 80-90% in the next 50 years, will require attention on energy supplies themselves, and no plans currently in place focus on this critical piece. Coal-fired electricity generation is simply not compatible with climate change mitigation, and all jurisdictions need to prioritize the transition to alternatives.

The most urgent gap in current policies is adaptation planning, which appears to be completely absent. One notable exception includes the City’s investments in the protection of natural areas (in 2009 City committed funds to purchasing land in order to protect it from development), which represents one important adaptation strategy.

### *Learning from the Leaders in Portland Oregon*

Leaders in the City of Edmonton can look to other municipalities for guidance in its development of a climate change action plan. Portland, Oregon’s Climate Action Plan is among the most progressive in the world, and serves as a useful comparison city. Their goal: reduce greenhouse

gasses 10% below 1990 levels by 2010; 40% below 1990 levels by 2030; 80% below 1990 levels by 2050. By 2008 they were 1% below 1990 levels (or a 19% reduction on a per capita basis).

Key highlights of their planning include:

1. Early action: First carbon reduction plan initiated in 1989.
2. Integrated response: integration of peak oil with climate change, inclusion of adaptation and mitigation planning.
3. Long-term Outlook: 50-year planning horizon.
4. Hard targets: Examples include: reduce total energy use of all buildings built before 2010 by 25%; 90% of residents able to walk or cycle to meet basic non-work needs.
5. Comprehensive: Inclusion of everything from transportation to solid waste and food to green job creation.
6. Participatory: Planners engaged a wide range of stakeholders to ensure policy support.

Specific strategies focus on both land use and transportation planning, including:

1. Development planning that focuses on mixed-use buildings.
2. New construction must be transit-oriented.
3. Business shift away from heavy industry.
4. Switch to low carbon power sources such as wind and natural gas.
5. Reduction of waste stream and methane gas capture at landfills.
6. Energy performance ratings and benchmarks required for all buildings.
7. Work with the state to change building codes.
8. Goal to establish 10MW renewable energy source locally.
9. Establishment of an “urban growth boundary.”

### *Moving forward at home*

The following are suggestions for future climate change planning in the City of Edmonton, including both adaptation and mitigation, although it should be noted many strategies complement both. First, eight suggestions in the area of adaptation, in no particular order:

1. Enhance preparedness for extreme events. Review current emergency evacuation plans and shelter capacity. All health and emergency services personnel should have emergency response plans for disease outbreaks and extreme weather events. Be aware that as a metropolitan hub, disasters hitting nearby rural regions will have implications for Edmonton as well.
2. Develop (and practice!) emergency response communication strategy. Clarify organizational jurisdiction BEFORE disaster strikes. Ensure open communication lines among all relevant response personnel, AND the public. Research on historic disaster events is informative here. Most importantly, the belief that members of the public tend to panic is a myth, one that is often used to justify lack of transparency. This lack of open communication has had far more deleterious effects on the ability to respond to disasters than has panic.
3. Identification of at-risk housing (flooding, storm damage and heat stress), target for upgrades.

4. Introduce redundancy in essential services where possible, especially electricity, water delivery, emergency services. What would happen if the power went out?
5. Plan green spaces to serve as ecological corridors for migrating species, and for drought tolerance, be prepared to develop response plans for exotic species invasions.
6. Drought contingency planning. Strict water conservation measures should be developed now. Support for xeri-scaping on public as well as private properties. Water audits should be included in environmental auditing. Applications for new business/industrial operations should be subject to strict water use guidelines. Subsidize low-flow fixtures, consider volume-based user fees. Encourage the use of residential rain barrels.
7. Upgrade physical infrastructure. Water management will be crucial. Water storage capacity should be evaluated in terms of a worst-case drought scenario; weaknesses in drainage capacity of sewer systems should be rectified.
8. Encourage household-level adaptation. Climate change education highlighting what climate change means for Albertans.

Mitigation reflects a global responsibility to address climate change. Some might consider a single medium-sized city as an insignificant contributor to a global phenomenon. On the other hand, cities are far more reflexive in the area of governance than are higher-order jurisdictions, and thus it is not surprising that cities all across North America and Europe are taking the lead in climate change mitigation. The task is by no means minor, however. One recent scholar concluded after reviewing potential energy sources for the 21<sup>st</sup> Century that nothing but a drastic reduction in production and consumption will suffice to mitigate climate change (Leahy 2008). The chart below is a useful means of identifying the sources of greenhouse gasses for the purposes of sector targeting for mitigation.

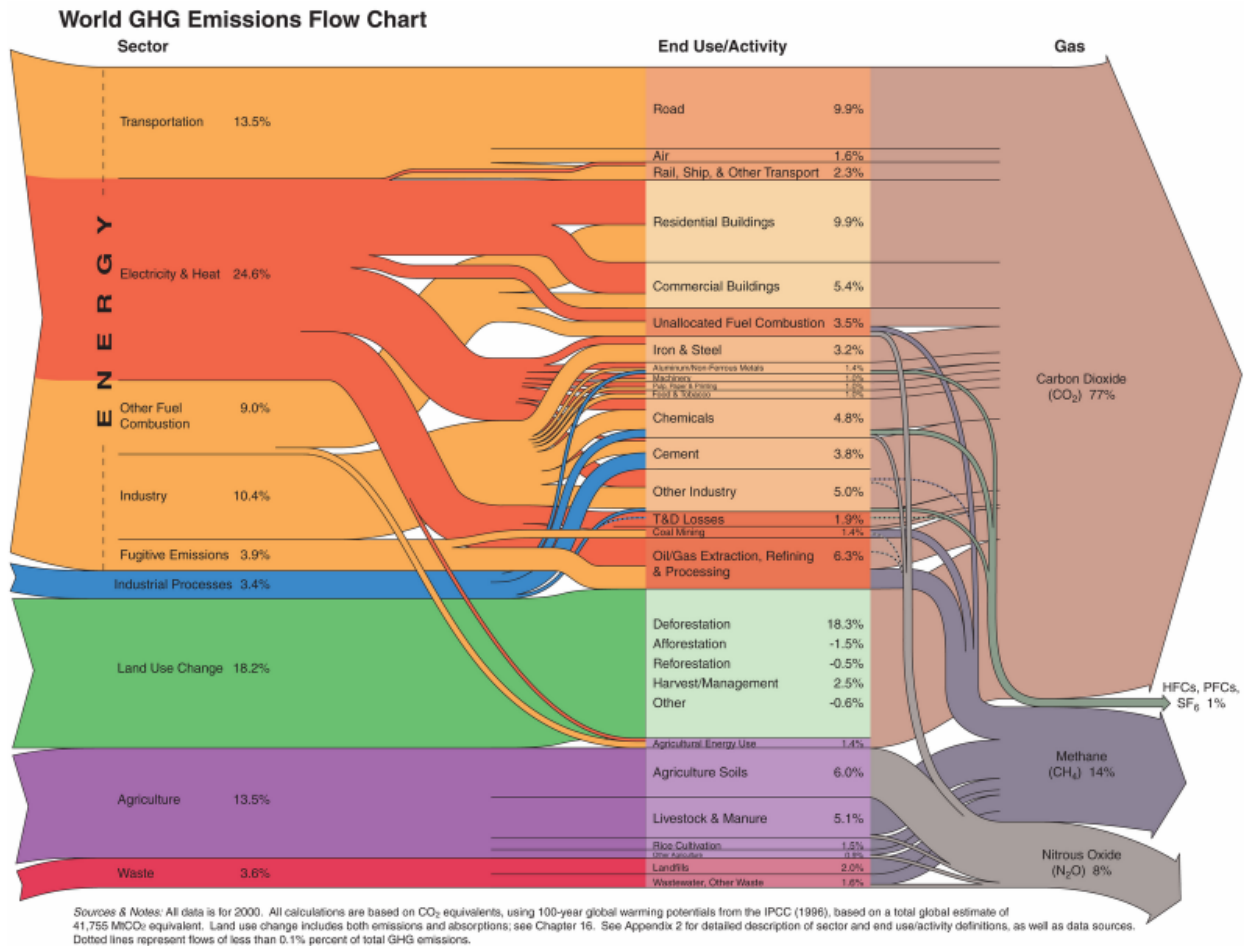


Figure 5. GHG Emissions Flowchart. Source: World Resources Institute, 2010. *Earth Trends Delivered*. [www.earthtrendsdelivered.org/node/231](http://www.earthtrendsdelivered.org/node/231) Accessed 4/29/2010.

One of the most important mitigation steps the City can take is the establishment of hard targets in specific areas. Targets are useful to serve as guide posts and a source of motivation. Mitigation planning should also be integrated with adaptation planning, and comprehensive. Finally, policies should focus on areas that can reap the greatest rewards at the least cost. These areas may not necessarily be the most politically attractive options (e.g. insulating older homes versus LEED standards in new buildings), and thus concerted efforts to maintain an inclusive, participatory planning process will be essential. Some specific areas for inclusion and suggested strategies are discussed briefly below.

### Transit

- Increasing use of public transit: Improve bus service times and scheduling; ensure access for physically disabled, elderly and families with small children; include bike racks on busses; increased designation of dedicated bus lanes on major routes in order to shorten commute times.



- Encouraging walking and cycling: More dedicated bike lanes; more bike racks at shopping centres and public spaces, consider secure lockers at LRT stops. More walkways—many of our main transportation corridors are entirely unfriendly to pedestrian traffic. Zoning that requires mixed-use development to ensure walk-able neighbourhoods.
- Discouraging private automobile use: Institute and market a voluntary “keep your car at home” day once a month. Work with major employers to develop plans to discourage private auto commuting.
- Removal of street-side parking on major routes, both to improve traffic flow and discourage driving by minimizing parking accessibility (e.g. 109<sup>th</sup> St; Whyte Ave).
- Institute and enforce strict no-idling policies.
- Require all new retail developments to be transit and pedestrian-accessible.

### **Buildings**

- Energy efficiency in existing building stock. Previous mitigation incentives have focused on new homes and furnace upgrades, but money may be much better spent on improving the insulation in older homes. Even high efficiency furnaces are not all that efficient without a solid “building envelope.”
- Energy efficiency in new homes. All new public and proposed business buildings should be built to LEED Gold standards. Building codes should be reviewed to ensure they accommodate green building designs.
- Subsidization for the purchase of high efficiency appliances.
- Require all mid- to large-size businesses to develop and implement an energy efficiency plan.

### **Energy Supply**

- Increase use of renewable energy sources. Technological advances in solar and wind power generation have reduced the costs and increased the flexibility of these power sources. All new buildings should at least be designed with future solar power generation in mind. Offer subsidies for installation of solar power for home owners.
- Eliminate coal-fired electricity. Develop long term plan for the replacement of coal-fired power plants.

## **Food and Agriculture**

- Encourage greater reliance on local food sources. Develop initiatives to increase the number of community gardens. Public school gardens are an option that should be considered given the large landbase devoted to the public school system and the educational opportunities offered by gardening. Offer competitions/rewards to restaurants for featuring local foods. Plan an annual local foods festival.
- Prevent development of regional farmland.
- Encourage home gardening. Promote neighbourhood home garden harvest swaps through engagement with community leagues.

## **Land Use**

- Protect green spaces. Prevent development incursions into existing green spaces.
- City landscaping. Prioritize planting of trees grasses and shrubs that are drought-tolerant and have high carbon absorption capacity.

## **Lifestyle**

- Development of pedestrian-only retail areas. Designate certain retail areas off-limits to non-essential motor vehicle traffic. Ensure their accessibility via public transit.

## **Waste Management**

- Discourage over-consumption/waste by introducing weight-based garbage collection fees.
- Work with local manufacturing businesses to minimize packaging.
- Offer courses in household composting. Develop composting options for multiple family housing.
- Minimization of construction waste. Sites for swapping re-usable materials and higher wastage fees for contractors should be put into place.

## References

Barrow, Elaine and Ge Yu. 2005. *Climate Scenarios for Alberta*. Prairie Adaptation Research Collaborative and Alberta Environment.

Bindoff, N.L. et al. "Observations: Oceanic Climate Change and Sea Level". *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Charlton, R. B., B. M. Kachman and L. Wojtiw. 1995. "Urban Hailstorms: A View from Alberta," *Natural Hazards* 12: 29-75. [1513]

Charron D.F., M.K. Thomas, D. Waltner-Toews, J.J. Aramini, T. Edge, R.A. Kent, A.R. Maarouf, and J. Wilson. 2004. Vulnerability of waterborne diseases to climate change in Canada: A review. *Journal of Toxicology and Environmental Health, Part A* 67:1666-1677.

Davidson, D.J., M. Haan and B. Parlee. 2008. *The Social Dimensions of Climate Change Vulnerability in Alberta: A Preliminary Assessment*. Report prepared for Alberta Environment, May. 292 pp.

Epstein, P. R. and E. Mills (eds.). 2005. *Climate change futures: Health, Ecological and economic impacts*. The Centre for Health and the Global Environment and the Harvard Medical School. November.

Etkin, D.A. 1995. "Beyond the Year 2000, More Tornadoes in Western Canada? Implications From the Historical Record," *Natural Hazards* 12: 19-27. [1545]

Etkin, D.A. and S.E. Brun. 1999. "A Note on Canada's Hail Climatology: 1977-1993," *International Journal of Climatology* 19: 1357-1373. [0615]

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: Synthesis Report*. United Nations Environment Programme.

\_\_\_\_\_. 2007a. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. United Nations Environment Programme.

Keatinge WR, Donaldson GC. The impact of global warming on health and mortality. *Southern Medical Journal*. 2004;97(11):1093-1099.

Koppe C, Kovats S, Jendritzky G, Menne B. Heat-waves: risks and responses. Health and Global Environmental Change. Series No. 2. World Health Organization, 2004. Copenhagen, Denmark.

Kovats RS, Edwards SJ, Hajat S, Armstrong BG, Ebi KL, Menne B and the Collaborating Group. The effect of temperature on food poisoning: a time-series analysis of salmonellosis in ten European countries. *Epidemiology of Infection* 2004;132:443-453.

Last J, Trouton K, Pengelly D. *Taking Our Breath Away: the Health Effects of Air Pollution and Climate Change*. David Suzuki Foundation, Vancouver, British Columbia, October 1998.

Lawford, R.G., T.D. Prowse, W.D. Hogg, A.A. Warkentin and P.J. Pilon. 1995. "Hydrometeorological Aspects of Flood Hazards in Canada," *Atmosphere-Ocean* 33 (2): 303-320. [1501]

Leahy, T. 2008. Discussion of 'Global Warming and Sociology.'" *Current Sociology* 56:475-84.

Lemmen, Donald, et al. 2008. *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Natural Resources Canada. Available at <http://adaptation.nrcan.gc.ca>.

Lincoln R. 2005. "Water: The effects of climate change on the availability and quality of drinking water." In: *Climate Change Futures: Health, Ecological and Economic Dimensions*. (eds P. R. Epstein and E. Mills). The Center for Health and the Global Environment, Harvard Medical School, Massachusetts.

Luterbacher, J., et al., 2004: European seasonal and annual temperature variability, trends, and extremes since 1500. *Science*, 303(5663), 1499–1503.

Mann, M.E., R.S. Bradley, and M.K. Hughes, 1999: Northern hemisphere temperatures during the past millennium: Inferences, uncertainties, and limitations. *Geophys. Res. Lett.*, **26**(6), 759–762.

McGeehin M.A., Mirabelli M. 2001. The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States. *Environmental Health Perspectives* 2001;109(supplement 2):185-9.

Mote, P.W., A.F. Hamlet, M.P. Clark, and D.P. Lettenmaier, 2005: Declining mountain snowpack in western North America. *Bull. Am. Meteorol. Soc.*, 86, 39–49, doi:10.1175/BAMS-86-1-39.

Nagel, J. T. Dietz and J. Broadbent. 2009. *Workshop on Sociological Perspectives on Global Climate Change, May 30-31 2008*. National Science Foundation.

National Aeronautics and Space Administration (NASA) 2010. "Arctic Sea Ice." Earth Observatory Feature Articles, available at <http://earthobservatory.nasa.gov/Features/SeaIce/page3.php>. Accessed May 5, 2010.

O'Connor, R.E. , B. Yarnal, R. Neff, R. Bord, N. Wiefek, C. Reenock, R. Shudak, C. L. Jocoy, P. Pascale and C. G. Knight. 1999. "Weather and Climate Extremes, Climate Change, and Planning," *Journal of the American Water Resources Association* 35 (6): 1411-1419. [1534]

Osborn, T.J., and K.R. Briffa, 2006: The spatial extent of 20th-century warmth in the context of the past 1200 years. *Science*, 311, 841–844.

Prospero JM. 1999. Assessing the impact of advected African dust on air quality and health in the Eastern United States. *Human and Ecological Risk Assessment* 5(3):471-9.

Perrow, Charles. 2007. *The Next Catastrophe: Reducing Our Vulnerabilities to Natural, Industrial, and Terrorist Disasters*. Princeton University Press.

Plotnikoff, R.C., M. Wright and N. Karunamuni. 2004. "Knowledge, attitudes and behaviours related to climate change in Alberta, Canada: Implications for public health policy and practice." *International Journal of Environmental Health Research*, 14(3):223-229.

Schwarz, H. E. and L. A. Dillard. 1990. "Urban Water," in Waggoner, P. E. (ed.) *Climate Change and U.S. Water Resources*. New York: John Wiley and Sons, 341-366. [1542]

Stone, R.S., E.G. Dutton, J.M. Harris, and D. Longnecker, 2002: Earlier spring snowmelt in northern Alaska as an indicator of climate change. *J. Geophys. Res.*, 10:7(D10).

Weber, M. D.J. Davidson and D. Sauchyn. 2008. *Climate Change Vulnerability Assessment for Alberta*. Alberta Environment.

White, R. and D.A. Etkin. 1997. "Climate Change, Extreme Events and the Canadian Insurance Industry," *Natural Hazards* 16: 135-163. [0139]