HOW ADAPTABLE ARE PRAIRIE CITIES TO CLIMATE CHANGE? CURRENT AND FUTURE IMPACTS AND ADAPTATION STRATEGIES

PARC
PRAIRIE ADAPTATION RESEARCH COLLABORATIVE

SUMMARY DOCUMENT

V. Wittrock
Saskatchewan Research Council

No. 05-03

Source: City of Saskatoon Website

Funding was provided by Prairie Adaptation Research Collaborative (PARC), Climate Change Action Fund (CCAF), Alberta Environment, Saskatchewan Research Council and the Prairie Adaptation Network.

This summary is a synopsis of a much larger study: Wittrock, V., E.E. Wheaton, C.R. Beaulieu. 2001. Adaptability of Prairie Cities: The Role of Climate Current and Future Impacts and Adaptation Strategies. Saskatchewan Research Council (SRC), Saskatoon, Saskatchewan.
SRC Publication No 1196-1E01.

The full report is at the PARC website (www.parc.ca). Click on the link to "research publications" and "Communities/Socio-Economic".

If you have any comments or queries on this summary please e-mail Virginia Wittrock (wittrock@src.sk.ca)

General e-mail for PARC: info@parc.uregina.ca
Telephone: 306-337-2300
Fax: 306-337-2301
Website: www.parc.ca

SRC Publication No: 10439-1E04

PARC
Prairie Adaptation Research Collaborative

SRC smart science solutions

Energy and Mines

PAN Prairie Adaptation Network

Canada

Alberta ENVIRONMENT

Introduction and Scope

Cities will likely experience some of the greatest impacts from climate change mainly because they are concentrations of population, wealth, infrastructure, and communication. Little research has been done to determine how cities might be affected by climate change or what cities should or could do to adapt to climate change. Current climate impacts are costly, disruptive, and possibly dangerous, especially the extreme events. Impacts can simultaneously affect several departments. The trends of changing weather and climate patterns and more extreme events is expected to increase with climate change. Therefore, cities are subject to considerable risk from climate change impacts and would benefit from improved adaptation. Adaptation is the adjustment in natural or human systems in response to expected or actual climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (McCarthy et al 2001).

Important climate impact areas include water resources, infrastructure, economic performance, energy, parks, recreation, pests, diseases, transportation, and human health. It is advantageous to determine the current and future possible effects of climate change on cities and what adaptation options are available and suitable. Some areas, such as transportation infrastructure development, require decision-making for the long term because actions taken now have effects over several decades. Adaptation is essential for optimizing beneficial climatic effects and minimizing adverse effects.

Climate change research regarding cities has focussed primarily on mitigation of greenhouse gases, leaving a tremendous knowledge gap about impacts and adaptation. This report is a first step towards examining the adaptability of Canadian cities by determining how they use climate information, how cities may be affected by climate change, and what adaptation options may be appropriate. Another main objective was to assess the robustness of the urban decision-making process to improve adaptability to climate change. The methodology included expert judgement and a critical literature review. The project focussed on several Canadian Prairie cities including Brandon, Edmonton, Grande Prairie, Prince Albert, Regina, Saskatoon, Swift Current and Winnipeg (Figure 1). These cities were chosen for several reasons including their population, their locations in different ecosystems, and their usage of different water sources.

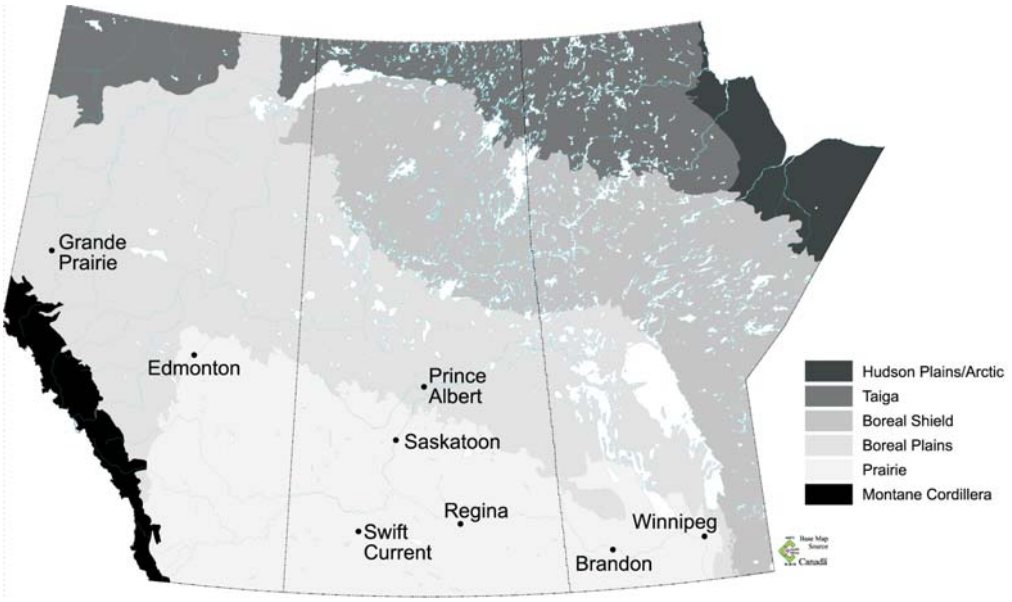

Figure 1. Cities in the study area.
Source: after Energy, Mines and Resources Canada and Environment Canada (1993)

Changing City Climates

All of the cities have undergone a long-term warming trend. Evidence from weather records dating back about 100 years shows a statistically significant increase in annual average temperatures for some of the cities. For example, the annual average temperature at Swift Current has risen 2.5°C since 1895 (statistically significant) while Grande Prairie's has risen by 0.6°C (not statistically significant) (Figures 2 and 3).

Summer temperature (June, July, and August) shows a statistically significant increase at all of the project's cities. Precipitation is highly variable and most of the seasonal and annual precipitation trends are not statistically significant.

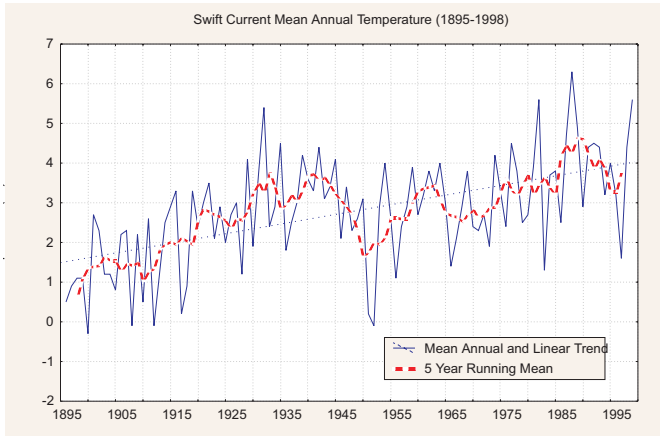

Figure 2. Mean annual temperature time series and trends at Swift Current (1895-1998).
Data Source: Vincent and Gullett (1999)

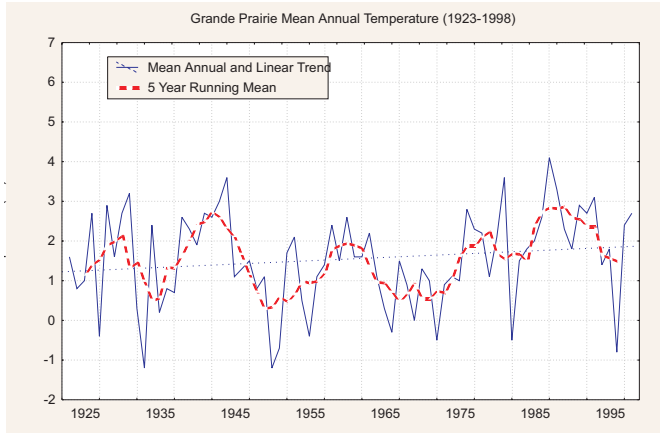

Figure 3. Mean annual temperature time series and trends at Grande Prairie (1923-1998).
Data Source: Vincent and Gullett (1999)

Climate Information Usage and Urban Decision-Making

The level of climate and weather information usage varies considerably among city departments. Several departments depend on personal experience, and do not use measured climate information. Planning departments tend to only use climate information as a sub-component of the Uniform Building and Accessibility Standards Act, and city bylaws, for example. Utility Services Departments use a large amount of climate and weather information partly due to weather's influence on water quantity and quality, for example. Transportation Departments use current weather information especially when severe weather warnings are issued because of the negative impacts on travel (Figure 4). Parks and Recreation Departments use climate and weather information for many purposes, for example, to help determine irrigation scheduling.

Figure 4. Example of various elements involved in the decision-making process of a city's transportation department.

Climate and weather tend to affect operations and planning of many city departments and other levels of government concurrently. For example, extreme weather events causing flooding have the potential to influence water quality, emergency services, transportation systems and health care facilities. Health impacts is another area that requires cooperation among many disciplines, departments, and areas.

Possible Future Climates of Selected Canadian Prairie Cities

The two global climate models (Canadian Global Climate Model1 - Greenhouse Gas Only Simulation and United Kingdom Hadley Centre Coupled Model 3 - Greenhouse Gas Only Simulation 1) indicate that the temperature is projected to increase for many decades (Figures 5-8). Precipitation will likely continue to be

highly variable, depending on the season. The projected above normal temperatures combined with the highly variable precipitation amounts may result in limiting moisture levels, especially in the summer.

These global climate model results do not include the influence of the urban heat island. This effect could significantly increase the amount of warming in large urban centres. This additional warming will increase air pollution and enhance the vulnerability of already at-risk people.

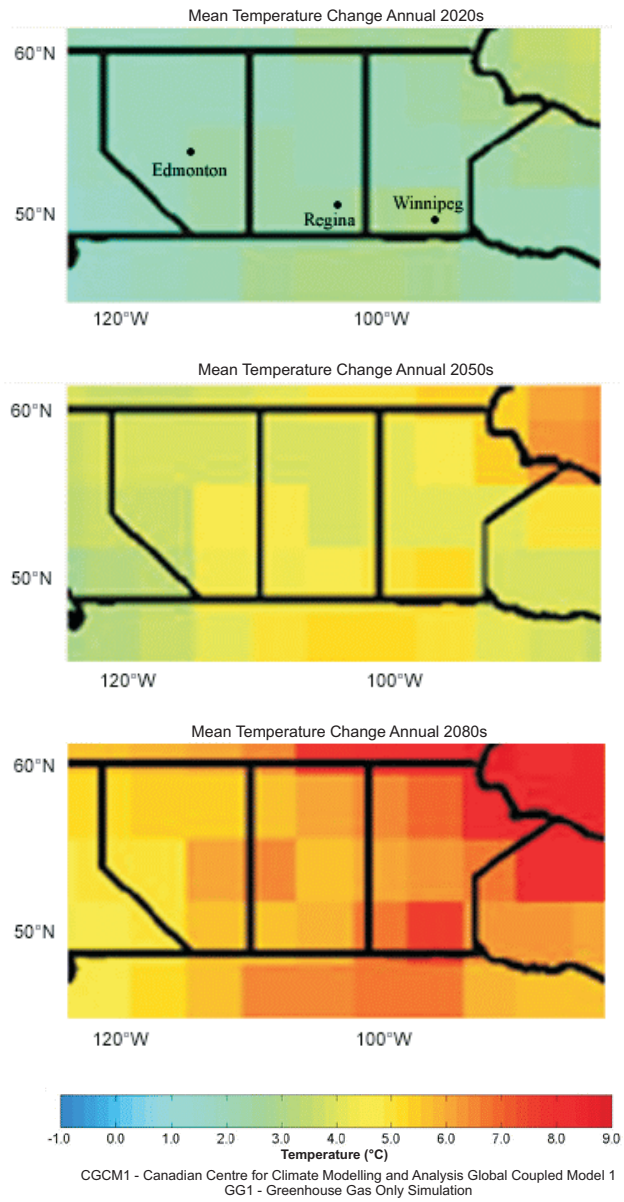

Figure 5. Canadian Global Climate Model 1 (greenhouse gas only) mean temperature changes for the 2020s, 2050s and 2080s. Source: Canadian Climate Impacts Scenarios Project (2001)

Potential Impacts of and Adaptation to Climate Change for Selected Canadian Cities

The use of climate information is an indicator of city adaptive capacity and vulnerability. Climate change is just one factor that affects cities. Interactions with many non-climatic factors must be considered as they can enhance negative climate impacts. When changes in temperature and precipitation occur, water levels are influenced, for example. This in turn influences

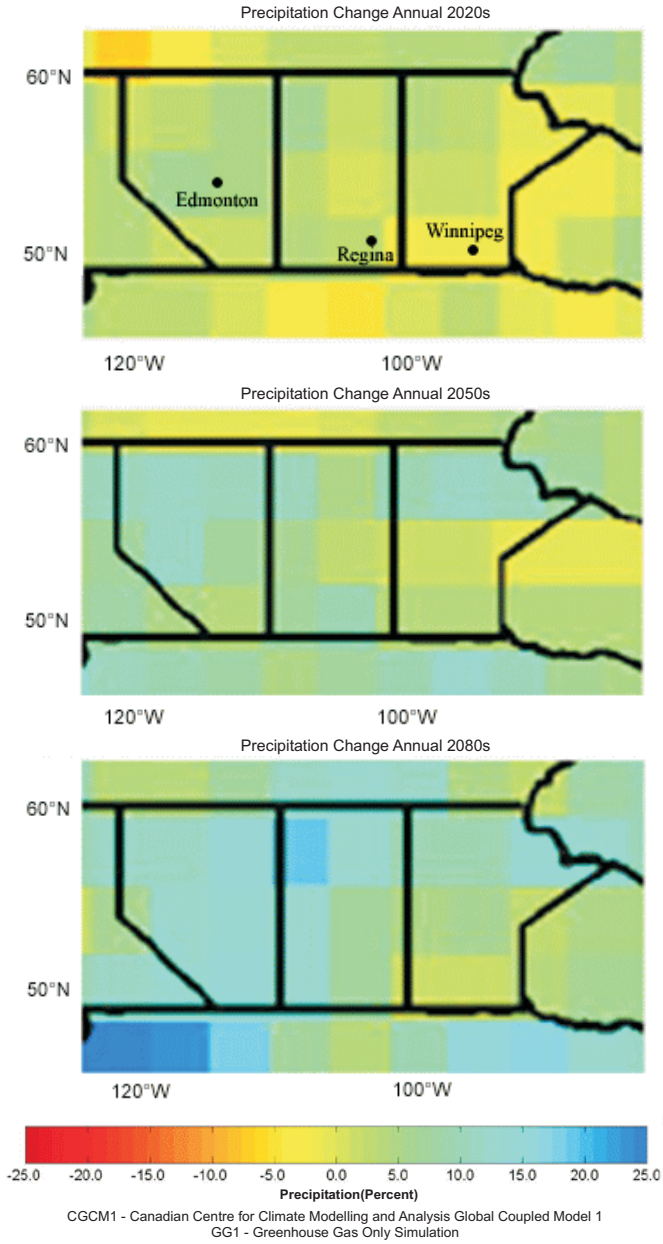

Figure 6. Canadian Global Climate Model 1 (greenhouse gas only) annual precipitation changes for the 2020s, 2050s and 2080s. Source: Canadian Climate Impacts Scenarios Project (2001)

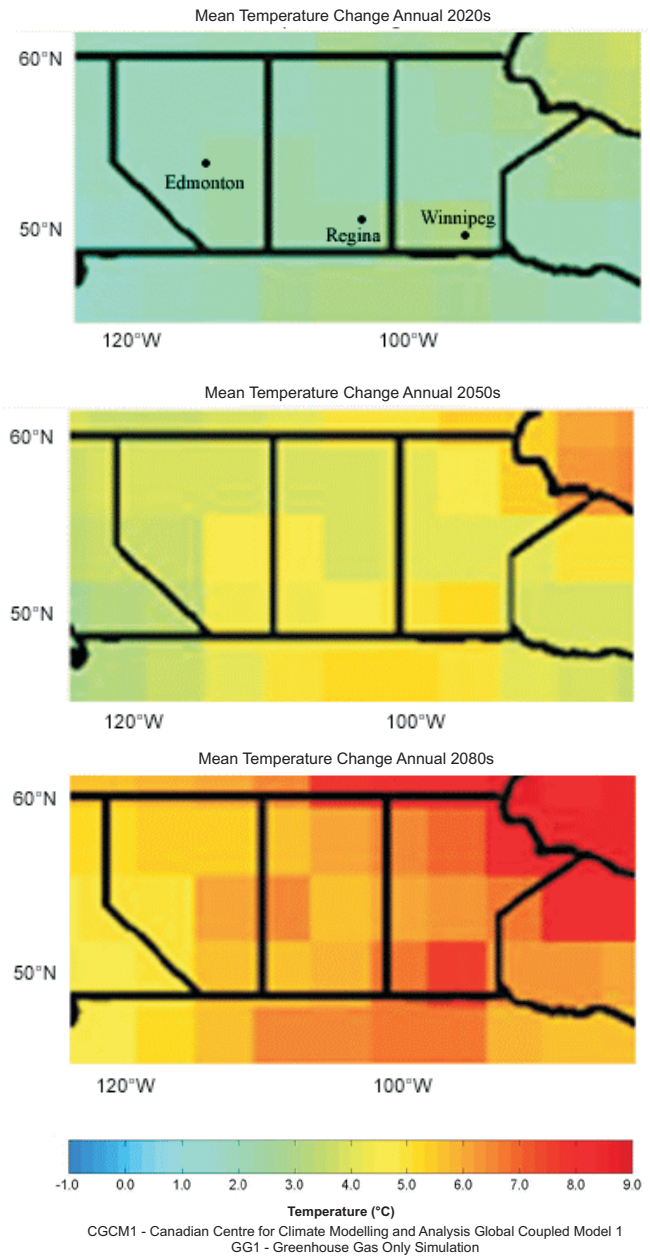

Figure 7. Hadley Centre Global Climate Model (greenhouse gas only) mean temperature changes for the 2020s, 2050s and 2080s. Source: Canadian Climate Impacts Scenarios Project (2001)

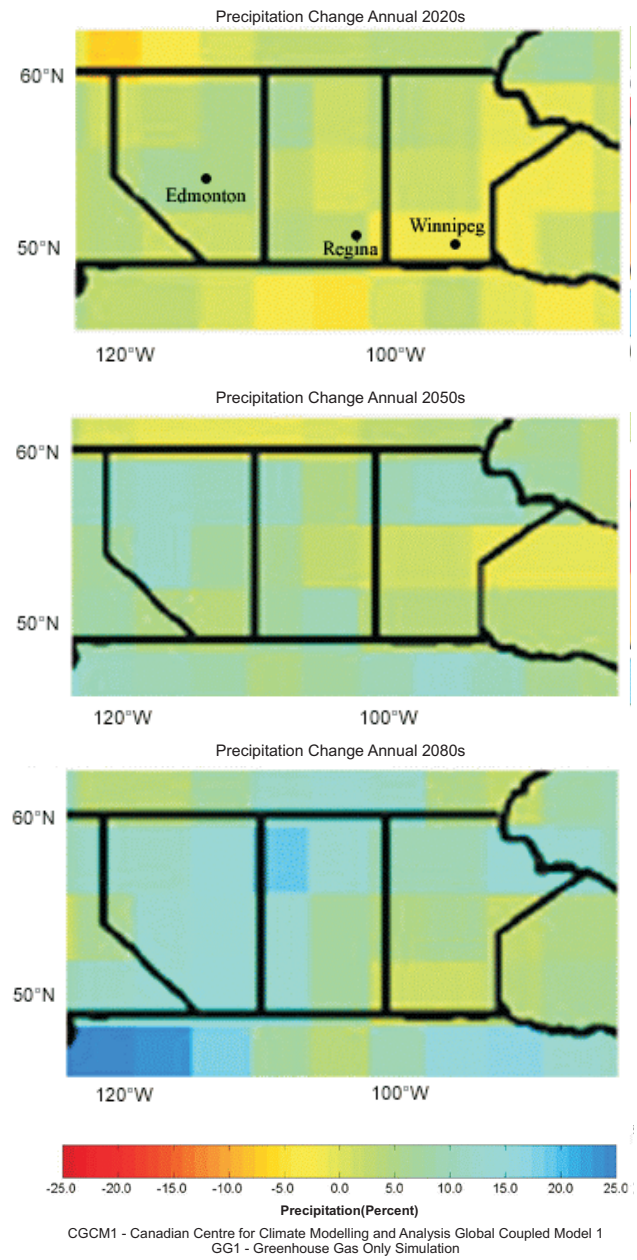

Figure 8. Hadley Centre Global Climate Model 3 (greenhouse gas only) annual precipitation changes for the 2020s, 2050s and 2080s. Source: Canadian Climate Impacts Scenarios Project (2001)

city departments which may lead to third order interactions, for example, with the involvement of city council, provincial and federal governments. Once the levels of climate change impacts are determined, city decision-makers need to consider a range of potential adaptive strategies and outcomes to indicate the robustness of those strategies (Figure 9). This may be done through risk assessment and by examining the co-benefits of the adaptation strategies, for example.

Planning Departments

Planning departments will have to assess how population growth and the potential for greater number of extreme weather events will affect property and people. The city development plan, zoning controls and sub-division regulations and building bylaws may need to be re-assessed. This may lead to having to change policies and bylaws to match the changing conditions (Figure 10).

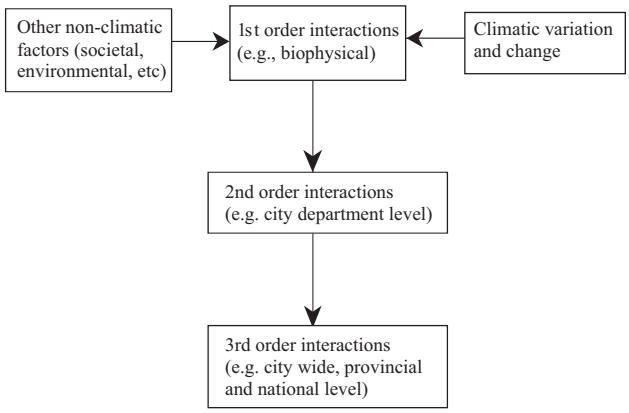

Figure 9. Scheme of Interaction Approach.
Source: after Parry and Carter (1998)

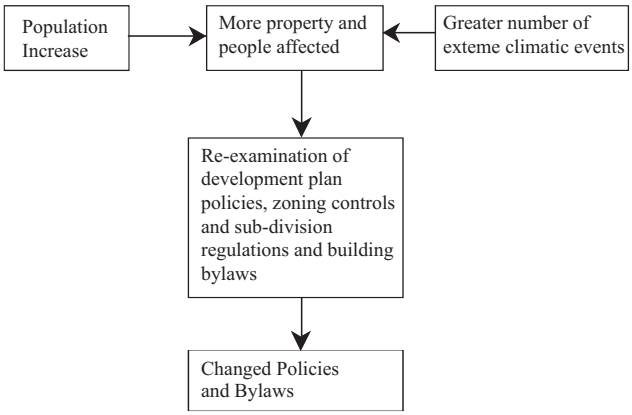

Figure 10. Impacts of climate change on planning departments

Utility Services Departments

The utility services departments have many city-specific challenges, but some impacts and adaptation strategies are common to all of the centres. For example, future water resource management plans must recognize the potential for significant and persistent departures from the historical climate and water (supply and quality) conditions. The result is that even cities which utilize water from glacier-fed rivers will have to start planning for a period when the rivers may supply less water at required times.

The change from historical climate and water conditions also influences waste-water management practices. Therefore, sustainable water management is required over the longer term to ensure that present actions do not limit the options of future generations, in terms of water quantity, quality and waste-water management (Figure 11).

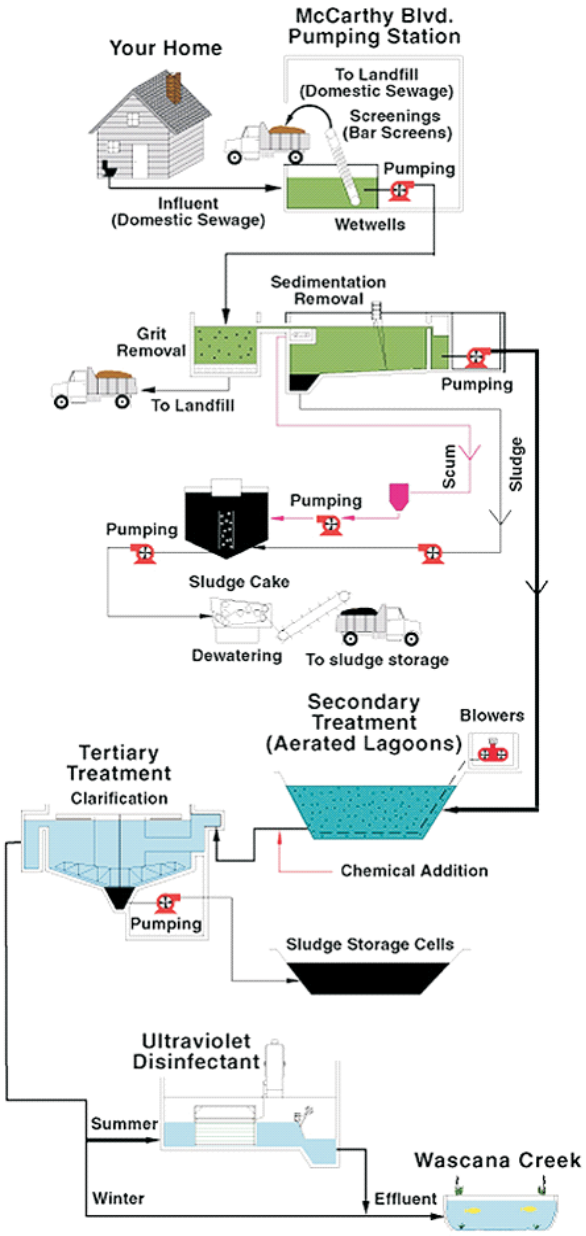

Figure 11. Waste-water treatment system for Regina. Source: City of Regina website

Transportation Departments

Transportation departments will experience changes in maintenance type and scheduling with climate change. For example, a change in maintenance type would occur if winter snowfall was accompanied by more freezing rain, resulting in the city requiring more sand and salt inventory in stock. Also, in the past 20 years, transportation departments have had to deal with an increase in the number of potholes. This trend will likely continue into the future because of the increase in freeze/thaw cycles. Many components of

the transportation infrastructure have an estimated life of at least 50 years. Therefore a modest increase in the initial investment at the time of design and construction to take into account climate change might reduce the need for costly repairs and modifications later (Figure 12).

Figure 12. Snow removal on the Prairies.
Source: City of Regina website

Parks and Recreation Departments

Parks and recreation departments may further modify park management strategies through changing vegetation management practices e.g., by planting different tree species and changing irrigation scheduling. Shifts in the number, types and seasonality of pests could result in changes in management practices such as pruning schedules (Figure 13). Adaptation measures for parks may include monitoring of spring and fall changes to park usage and vegetation (e.g., earlier leafing out time), assessing the implications for park maintenance and use, deciding on adaptation strategies and when and how to implement actions. Also the department should monitor the effectiveness of the adaptation measures and make required improvements. Figure 14 gives an indication of the amount of money spent on pest management for the 1989 to 1998 period. It would be useful to assess where the expenses increased and if the increased expenditures obtained the desired results.

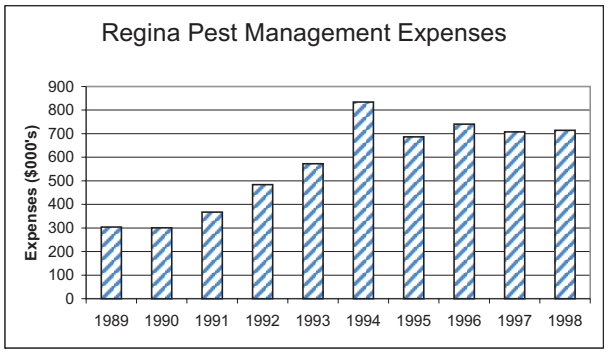

Figure 14. Regina pest management expenses data.
Source: City of Regina personal communication (2000)

Figure 13. Pruning elms.
Source: City of Winnipeg website.

Extreme Weather

Extreme weather events have the potential to simultaneously affect many departments. Extreme weather is of concern to the utility services department because the life span of water and waste-water infrastructure is long, therefore, the infrastructure will have to handle the climatic changes that will occur in the next 50 or so years. The transportation infrastructure is also affected by extreme events. For example, if the storm sewer system is unable to manage an extreme rainfall event, underpasses in the city are flooded resulting in traffic flow problems. Drought will likely be as challenging and possibly more challenging for decision-makers. City decision-makers should determine the critical threshold of drought for their city and how these may be affected by climatic changes. A city is usually able to manage

Figure 15. Edmonton tornado, July 31, 1987
Source: http://datalib.library.ualberta.ca/tornado/

one drought year, but is less able to manage three or more consecutive drought years. Therefore, it is necessary to determine long-term water demand and sewage disposal requirements. Achieving a disaster-resistant community requires holistic problem solving, cooperation and integration among all groups and government levels and also requires long-term thinking.

Health and Safety

Health is another area that needs cooperative and collaborative responses from various departments to deal with the potential impacts of climate change. The city municipal government is the first level of government available to Canadian citizens when a natural disaster occurs. This is a serious responsibility for cities, their emergency services, and the health care system because cities need to be able to respond quickly to extreme weather events in conjunction with the associated health emergencies. The health and well-being of residents is a function of factors including the wealth of the community, the equality of community members through public and private insurance and the ability of the city to adapt to emergency situations. Therefore, it is important that cities assess the potential impact of extreme events through examination of risk, exposure, vulnerability and the capability and response rate of the emergency services.

Case Studies of Historical Extreme Weather Events and Cities

Three case studies were used to examine current climate sensitivity of cities as well as their vulnerability, and adaptive capacity. Major weather events were selected for the assessment, including Edmonton's 1987 tornado (Figure 15), Winnipeg's 1997 flood (Figure 16) and Regina's 1988 drought. These cities were chosen because they have experienced a recent extreme event resulting in adaptation strategies being implemented that may lessen future impacts of similar extreme events.

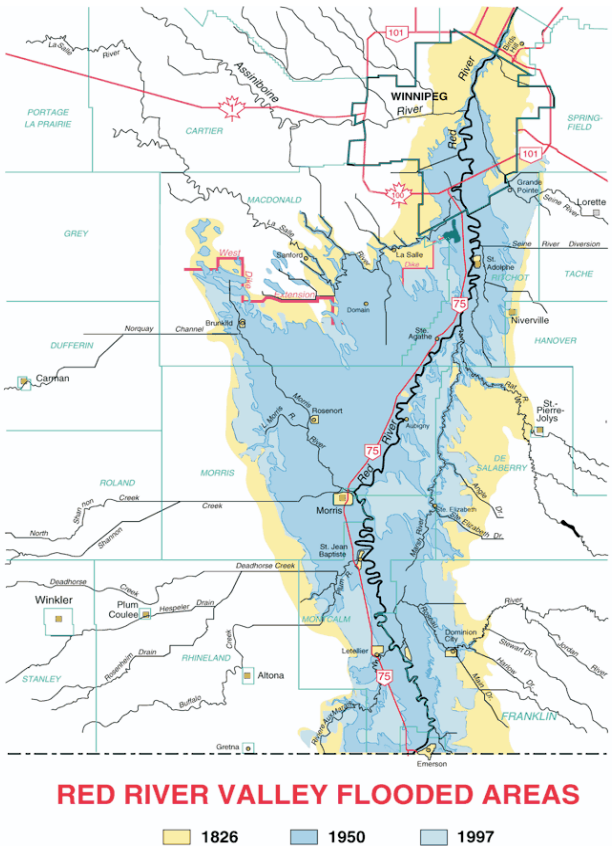

Figure 16. Red River Valley flooded areas 1826, 1950, 1997.
Source: http://www.gov.mb.ca /conservation/watres/1826_fld_area.htm

Major floods, similar to the 1997 flood that affected Winnipeg, have occurred in the past. Previous flood events led Winnipeg to build a dyke and diversion system. This system decreased the negative impacts of subsequent floods. However, it has been recommended that the dyke and diversion system reliability and

structures be re-examined because the design capacity was exceeded in the 1997 event at the Winnipeg Floodway by 200 centimetres and by 80 centimetres for the River Channel. Also, the timing and severity of floods will likely shift with climate change.

All of the project's cities have experienced flooding. With climate change, it is important that cities examine how their potable water and waste-water facilities will be affected by high water levels and they should take appropriate actions. Major flood events tend to involve many departments and different levels of government and non-government agencies. It is important that pro-active, re-active and cooperative plans be in place to cope with flood events (Figure 17).

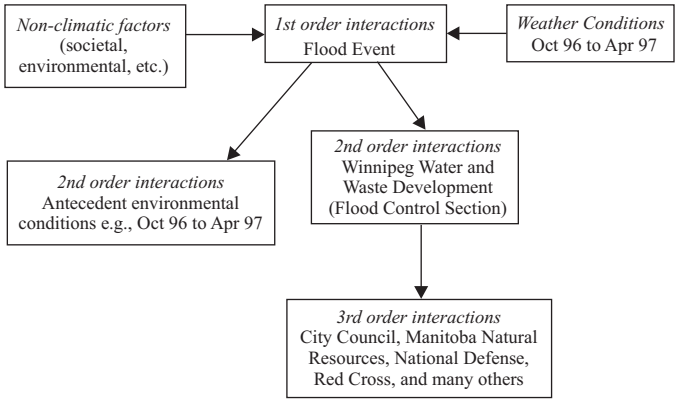

Figure 17. Impacts of the 1997 Flood in Winnipeg

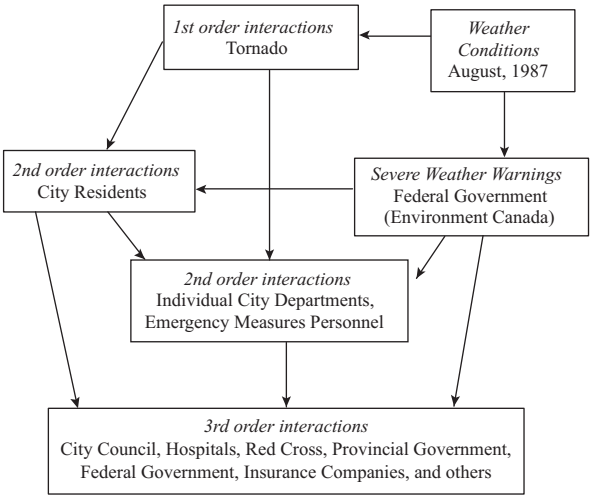

Figure 18. Impacts of the 1987 Edmonton tornado

Tornadoes occur every year in the Canadian Prairies and they are likely increasing. Unlike certain flood events, tornado forecasting has a very short time frame to issue warnings. Therefore, it is important that cities have emergency response strategies in place, similar to Edmonton's. The emergency strategy should include all affected city departments, medical services, media and the federal and provincial governments (Figure 18).

Drought often occurs on the Canadian Prairies and will likely become more common with climate change. Cities and their various departments will have to further develop their adaptation strategies to cope with drought. These strategies need to be pro-active and re-active so that the negative drought impacts can be minimized. Regina has implemented many drought contingency plans and is a good starting-point model for other cities (Figures 19 and 20).

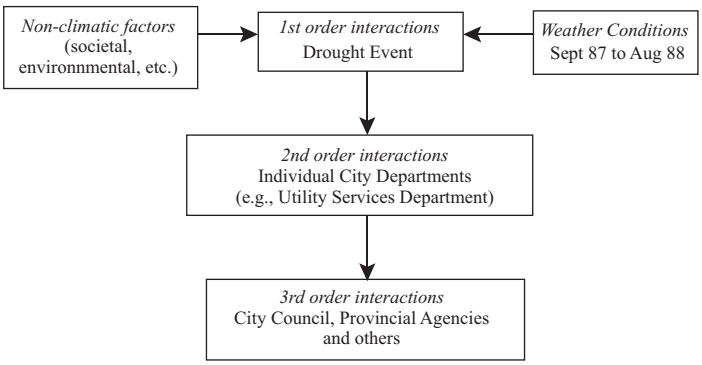

Figure 19. Impacts of the 1987/1988 drought on Regina

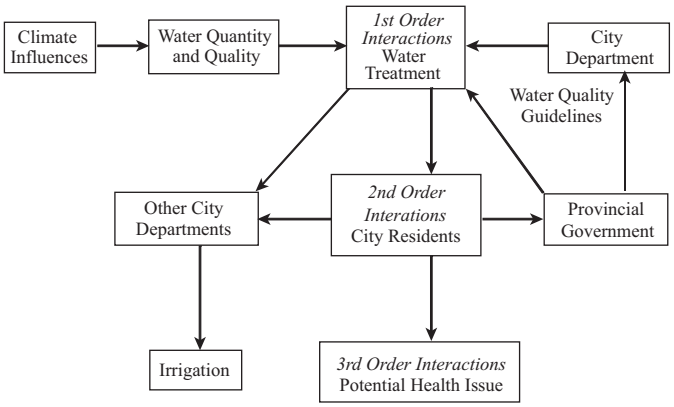

Figure 20. Impacts of water quality on Regina due to drought conditions.

Recommendations

Several general recommendations are made to improve climate change adaptation strategies, including:

- Budget planning should permit sufficient flexibility to deal with extreme weather/climatic events.
- Better communication and collaboration between climatologists and people in planning, operations, and public policy are needed. This cooperation would improve and sustain the quality of life and would buffer against future climate change hazards.
- Community outreach is important. It results in more awareness of climate change issues and creates a clearer understanding of the impacts and potential adaptation measures available to decision-makers and city residents.
- In urban areas, climate change will likely be augmented by the urban heat island effect. Therefore, the changes in cities may be more extreme than in rural areas, and more surprising than expected. This effect needs to be considered in planning adaptation strategies.
- A major research gap is the use of socio-economic scenarios and indices related to bio-physical and economic aspects of interest to city decision-makers.
- Most cities are able to cope with short-term climate change but at a cost and with possible disruptions and likely residual effects. City decision-makers will likely respond slowly to the climate change issue. Implementing "no-regrets" adaptation strategies are important because some communities will probably not have strategies in place for at least another 15 to 20 years.
- Cities should implement monitoring and evaluation programs as an on-going activity, conducted in parallel with other adaptation strategies. Continuous evaluation is important to determine if supplemental adaptation measures need to be considered

Conclusions

The report by Wittrock et al. (2001) determined several aspects of baseline adaptive capacity of cities, including the use of climate information, awareness of climate change, case studies to assess current vulnerability and adaptive capacity. Climate change will have many serious effects on cities. Therefore, it is important that preparation for these impacts begin. Currently, awareness and adaptation strategies are inadequate and cities are vulnerable. Increased information exchange is a critical start towards decreasing vulnerability and decreasing the costs of adaptation. Increased use of decision-making processes or tools that include information about climate impacts and adaptations is required. Increased research is required to further develop or improve such decision-making tools that include climate information and are appropriate to climate change adaptation.

Research work to improve our understanding of impacts of and adaptation to climate change affecting cities is sparse and urgently needed. Researchers have insufficient information to assess relative degrees of climate impacts to determine the most important, costly or dangerous impacts. Yet, it is a vital research area because of the importance of cities and their vulnerability to climate change.

References

Atmospheric Environment Service. 2000. Canadian daily Climate Data on CD-ROM - Prairies. Environment Canada, Downsview, Ontario.

Canadian Climate Impacts Scenarios Project. 2001. Canadian Climate Impacts Scenario (CCIS) Project Website [web page]. Available at: http://www.cics.uvic.ca/scenarios/.

Energy, Mines and Resources Canada and Environment Canada. 1993. Terrestrial Ecoregions of Canada [Web Page]. National Atlas of Canada. Accessed 2000. Available at: http://atlas.gc.ca/english/quick_maps/index_5edition.htm

Environment Canada. 1993. Canadian Climate Normals 1961-1990 on Diskette. Version 2.0E. Canadian Climate Centre, Environment Canada. Downsview, Ontario.

McCarthy, J.J., O.F. Canziani, N.A. Leary, D.J. Dokken, and K.S. White. 2001. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Cambridge University Press, New York, New York. Intergovernmental Panel on Climate Change [IPCC] Working Group II. 1032 pp.

Parry, M. and T. Carter. 1998. Climate Impact and Adaptation Assessment. Earthscan Publications, Ltd., London, United Kingdom. 166 pp.

Vincent, L.A. and D.W. Gullett. 1999. Canadian Historical and Homogeneous Temperature Datasets for Climate Change Analyses. International Journal of Climatology, 19:1375-1388.

Wittrock, V., E.E. Wheaton, C.R. Beaulieu. 2001. Adaptability of Prairie Cities: The Role of Climate Current and Future Impacts and Adaptation Strategies. Saskatchewan Research Council (SRC), Saskatoon, Saskatchewan. SRC Publication No 11296-1E01.

Acknowledgments

This main project (Wittrock et al. 2001) was supported in part by the Prairie Adaptation Research Collaborative, the Climate Change Action Fund, along with Alberta Environment, Saskatchewan Research Council, Prairie Adaptation Network and Saskatchewan Energy and Mines. The many other partners included representatives from the cities of Regina, Winnipeg, Edmonton, Saskatoon, Grande Prairie, Swift Current, Brandon and Prince Albert. Other partners were Governments of Saskatchewan and Manitoba, Environment Canada, Architectural Association of Saskatchewan, SaskPower, and the University of Alberta. These partners were members of our Climate Advisory Group to which a very special thanks is extended.

Other publications in the PARC Summary Series:

- Climate Change Impacts on the Island Forests of the Great Plains and the Implications for Nature Conservation Policy
- Aridity on the Canadian Plains: Future Trends and Past Variability
- Socio-Economic Vulnerability of Prairie Communities to Climate Change
- Political Climate Modeling: Predicting socio-political responses to climate change in the Prairie Provinces
- Assessment of Climate Change on the Agricultural Resource of the Canadian Prairies
- Fire Behavior Potential in Central Saskatchewan under predicted climate change
- Exploring the Impacts of Climate Change and Adaptation Options for Boreal Forest Ecosystems
- Isi Askiwan – The State of the Land: Prince Albert Grand Council Elders' Forum on Climate Change