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Planning for climate change adaptation: lessons learned from a community-based workshop

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ABSTRACT

Adaptation is now broadly accepted as a necessary response to climate change. Local adaptation strategies should be developed with decision-makers familiar with the unique characteristics of a community. As part of ongoing research on adaptation in Prince George, British Columbia, Canada we hosted a workshop with City staff and community stakeholders to build local capacity and initiate an adaptation strategy. Past climate trends and future scenarios were used to gain a better understanding of the changes occurring and expected in the region. The highest priorities identified for Prince George relate to forest fires, flooding, emergency response to extreme events, water supply and transportation infrastructure. The workshop framework represents a tool which communities can apply to outline adaptation priorities within a limited time frame.

1. Introduction

When climate change became an international concern in the 1980s, mitigation was deemed to be the appropriate strategy to address the challenge. Planning for adaptation (i.e. for the effects of changes in the climate) was viewed by many as irresponsible because, if societies could have agreed on and adhered to legislation to stabilize atmospheric greenhouse gas (GHG) concentrations, many impacts could have been avoided and adaptation would not have been necessary (Paavola and Adger, 2006; Pielke et al., 2007). Unfortunately at present there are still no binding international agreements to reduce global carbon emissions. Also, because of GHGs already in the atmosphere, changes in the climate will continue for at least the next 50 years regardless of mitigation actions (Pielke et al., 2007; Snover et al., 2007). Furthermore, the ability of natural systems to sequester and store carbon is being steadily compromised due to ocean acidification, permafrost degradation, deforestation and other environmental changes (IPCC, 2007a). Therefore adaptation is a necessary response to climate change, whether or not mitigation occurs. Although not the focus of this article, mitigation remains an important priority which will dictate the severity and duration of future climate impacts (IPCC, 2007b,c; Swart and Raes, 2007; Zhang et al., 2008).

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Adaptation can be an effective focus for community action on climate change. Unlike mitigation – which requires international participation and long time periods to be effective – local and regional governments can move quickly to plan for specific local impacts, strategies can provide tangible benefits to residents and policies can be created with the input and participation of local stakeholders (Jacques, 2006; Füssel, 2007). Some common barriers preventing communities from implementing adaptation actions include a lack of funds due to a limited tax base, a shortage of existing case study examples and a paucity of expert guidance and advice (Jacques, 2006; Smit and Wandel, 2006). Adaptation continues to lag significantly behind mitigation in climate research, and there are very few examples of adaptation plans and actions focused on human systems (Berrang-Ford et al., 2011). Research shows that it is important to incorporate adaptation strategies into existing plans and policies, as actions are rarely implemented with adaptation being the primary motivator (Füssel, 2007; Smit and Wandel, 2006) and planners in British Columbia (BC) prefer adaptation to be incorporated into existing documents rather than separate stand-alone plans (Picketts and Curry, 2011).

Adaptation is no longer simply a challenge to be addressed by people engaged in the environmental sector (Juhola and Westerhoff, 2011), and involving community stakeholders in adaptation planning leads to better results for many reasons. Some of these reasons, outlined by França Doria et al. (2009), Jacques (2006), Swart and Raes (2007) and Zhang et al. (2008), include:

- community members possess important local knowledge of the unique social, environmental and economic conditions of an area;
- engaging with local stakeholders promotes greater understanding and awareness of climate change and its impacts;
- working with a community encourages future buy-in and support for implementation;
- adaptation success is best evaluated by those affected by and adapting to impacts; and
- the public is more likely to listen to local stakeholders than external experts.

The purpose of this article is to explore how communities can begin planning for climate change adaptation. We provide an overview of the case study community of Prince George and, in the methods section, describe how academics, City staff, climate modellers and members of a regional non-governmental organization created and facilitated a local adaptation workshop. The information presented in the workshop and the outcomes – which were used to determine local adaptation priorities and to envision how implementation should proceed – are summarized in the results section. A framework for outlining an adaptation strategy with local decision-makers within a short time-frame is also presented as a tool which communities and other small organizations can use and build upon. The paper concludes with a discussion on the challenges and successes of the Prince George workshop, and how communities can effectively prepare for adaptation. Local practitioners, researchers and policy-makers can use the results of the workshop and apply the framework as they continue exploring how communities can best prepare for expected impacts and become more resilient to unexpected changes and events.

1.1. *Case study community: Prince George*

Prince George is a City of 77,000 people located at the confluence of the Fraser and Nechako rivers near the geographical centre of BC, approximately 800 km north of Vancouver and 700 km west of Edmonton, Alberta. The City centre occupies a valley at an elevation of 575 m and precipitation ranges from 450 to 1000 mm per year in the area (Picketts et al., 2009a). Average local summer day-time high air temperatures are 20 °C and average winter night-time lows are −12 °C (City of Prince George, 2011). Prince George has close ties to the forestry sector, and 29% of local jobs rely on logging and forest products industries (BC Government, 2010). The City is known as the "northern capital" of BC, and acts as a hub for surrounding towns.

As a northern community, Prince George is experiencing rates of temperature change nearly double the global average (Walker and Sydneysmith, 2008), and is already being affected by impacts related to climate change. Most significantly, the proliferation of the mountain pine beetle (*Dendroctonus ponderosae*) has had profound economic, environmental and social effects on the region. Due to less frequent cold winter temperatures the beetle population has expanded remarkably, and infestation now covers over 8 million hectares of forest in central BC (BC Government, 2006). The City has also experienced recent river flooding events, and has major problems with road deterioration related to increased freeze–thaw cycles during winter months (Picketts et al., 2009b). Prince George has a high adaptive capacity (i.e. ability to respond to and prepare for climate impacts) due to an engaged senior City staff, available funds for adaptation, access to research and modelling expertise, and a progressive political environment (Smit and Wandel, 2006).

Several activities have raised awareness and understanding of the need for adaptation in Prince George since researchers and City staff partnered to explore adaptation in 2007. Most notably, a previous workshop occurred as part of the Planning Institute of BC's 2008 annual conference. This event was designed to educate professional planners and to discuss adaptation strategies for the case study community of Prince George. Although it did not yield results that could be used to envision adaptation priorities, the event generated considerable local interest and brought together many stakeholders who have remained engaged in adaptation (Picketts and Curry, 2011).

The research utilizes the case study approach to examine specific phenomena (adaptation) in a bounded system (Prince George) (Smith, 1978). Case studies are ideal for asking questions about complex social phenomena and for understanding the role of process and context in affecting change. Although case studies provide limited basis for scientific generalization (Yin, 1989), we anticipate that the workshop results will be of relevance to other communities (particularly northern and smaller centres), and the framework generated will be broadly applicable to communities and small organizations addressing adaptation. Because climate change is happening more rapidly in northern regions (Salinger, 2005), more southerly cities and towns can learn from northern communities (such as Prince George, which is situated at 54°N latitude) that are already responding to challenges they may expect to experience in the future.

2. Methods

This paper reports on qualitative research to illustrate how adaptation has progressed in a northern Canadian community. The primary research exercise was a workshop in November 2008 in Prince George with a group of 34 invited participants. Attendance was limited to encourage full participation in focus group and plenary sessions. City managers were asked to attend and to also recommend staff members who would have the best knowledge of how climate change would affect local infrastructure, land use and operations. Response was excellent and representatives were present from a range of City sectors, with multiple staff from long term planning, current planning, environment, utilities and transportation. Once the organizers were satisfied that the City sectors were properly represented, remaining spaces were made available to people from relevant external organizations and interested parties. Although civil society was not largely represented in the workshop, public feedback on adaptation priorities has been gathered through other mechanisms (Picketts et al., 2009b). Facilitators stressed that all participants engage in productive conversation in an open, non-hierarchical and non-political manner.

The appropriate Prince George senior staff-members and community stakeholders showed interest in contributing to local adaptation planning. However, time was the biggest drawback to participation, and many indicated that they could not commit to being part of a committee or attend an event longer than one day. Therefore the research team designed a workshop to efficiently generate the most useful information for a community adaptation strategy.

Although there is a shortage of implemented actions, resources and frameworks exist to assist local governments as they create adaptation strategies. Guides by Bizikova et al. (2008), Bruce et al. (2006), the City of Chicago (2008) and Snover et al. (2007) were reviewed, and the common overarching steps for community adaptation were distilled as: build capacity; identify local impacts and vulnerabilities; and determine adaptation priorities and implement actions. The methods used to achieve these outcomes in the workshop are outlined below.

2.1. *Building capacity*

The workshop began with an introductory presentation to clearly define and differentiate between adaptation and mitigation. This information is important as previous research shows a low level of knowledge and experience of adaptation among planners in BC (Picketts and Curry, 2011) and among practitioners around the world (IPCC, 2007b; Storbjörk, 2010). The climate information also served an important capacity building function, as did the previous adaptation work in Prince George (outlined in Section 1.1). Facilitators explained the key role participants had in adaptation planning as experts with important local knowledge.

2.2. *Identifying local impacts and vulnerabilities*

Researchers and City staff recognized the need for quality climate information to assist local stakeholders as they plan for climate change early on in the research process (NZMOE, 2008) and partnered with the Pacific Climate Impacts Consortium (PCIC) of the University of Victoria. Historical climate trends, information about regional climate variability and future climate projections for the region were created. This information was provided in document form to participants for review before the workshop and presented at the event by a PCIC climatologist, with time allocated for discussion. A detailed overview of the climate information presented is included in Section 3.1.

Workshop attendees were then divided into four focus groups, with each group containing representatives from different City sectors, for discussions on linking the climate projections to impacts in Prince George. Focus groups are a fast, and often enjoyable, research method that encourages communication between participants to produce quality feedback (Kitzinger, 1994). Careful planning and proper facilitation is crucial to allow groups to effectively share their ideas, and to encourage conversations to flow among the participants (Krueger and King, 1997). Therefore each group had an experienced facilitator who was briefed beforehand on the purpose of the exercise. Groups prioritized three top impacts, and could also indicate up to two other important impacts. These outcomes were used to create the master list of priorities.

2.3. *Determining priorities and outlining implementation*

The researchers compiled the focus group outcomes into a master list representing all of the appropriate impacts from the focus groups, and presented it back to the plenary for finalization. Participants were then instructed to individually examine each impact from the master list and evaluate it in terms of its risk, outline the City sectors affected, indicate top plans for implementation and offer further comments and ideas related to the impact.

The risk evaluation was the most important feedback gathered from the participants, and these results were used to prioritize the impacts. Participants ranked the 'likelihood and timing' of each impact on a scale from one (very unlikely) to five (occurring now) and then the 'consequence of inaction' on a scale of one (minimal or no consequence) to five (catastrophic consequences in costs and human safety). The mean likelihood and consequence values are multiplied to measure the overall risk of an impact. Means, rather than medians or other statistical metrics, were used for the rankings so that all feedback (outliers included) from the broad range of respondents was reflected in the final values. The exercise was based on the concept of risk analysis, modelled from the City of Chicago (2008) framework. Similar frameworks are outlined by Bruce et al. (2006), Snover et al. (2007) and the United Kingdom Climate Impacts Programme (UKCIP, 2010). A comparison of this framework to the risk criteria outlined by the Intergovernmental Panel on Climate Change (IPCC, 2007b) is included in the Appendix.

Participants indicated up to five City sectors that should be involved in addressing each impact. The City sectors were defined and organized into services before the workshop by senior City staff. Options for outside agencies were included if participants felt that addressing the impact was beyond the jurisdiction or capacity of the City. Participants were asked to indicate the top plan where they believed implementation strategies should be incorporated for each impact. They were also invited to outline potential adaptation actions, ways to make Prince George more resilient, groups or individuals that should be involved in creating strategies, and further information needs.

3. Results

This paper focuses on the results of adaptation research in Prince George, and the broader challenge of addressing adaptation at the local level. An overview of the information selected for presentation at the workshop and how outcomes were organized is discussed first. The workshop results for Prince George are then presented and a workshop framework is proposed for communities and organizations to apply and build upon as they pursue climate change adaptation.

3.1. *Workshop information*

3.1.1. *Climate information*

Deciding what climate related information would be presented and how to convey this information was a significant challenge in preparing the workshop. Organizers sought to present a comprehensive overview of past and future climate information in a short period of time. A summary of the climate information for Prince George presented at the workshop (and included in the report) is as follows.

The presentation began with an explanation of the differences between climate normals, climate change and climate variability. Climate normals are temperature and

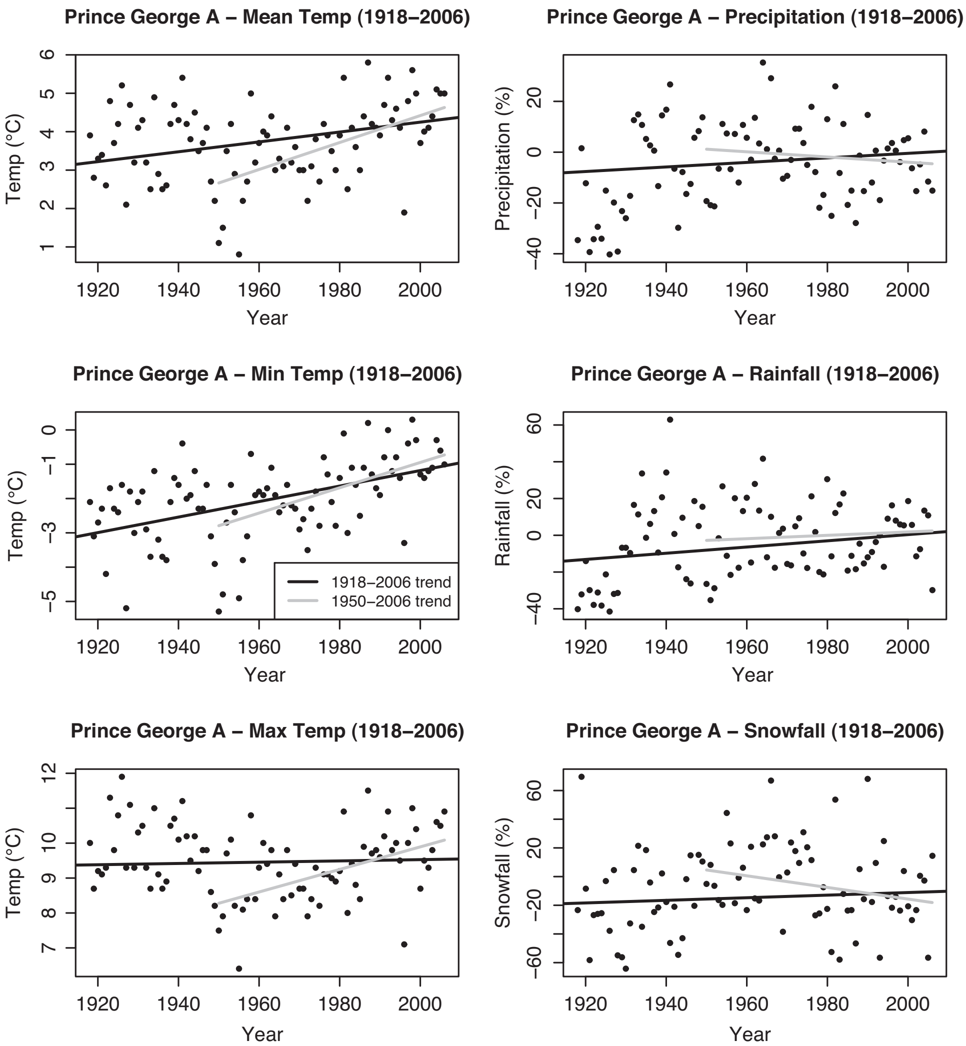

Fig. 1 – Trends for the Prince George airport (A) climate station for 1918–2006 annual mean (a) air temperature, (b) minimum temperature, (c) maximum temperature, (d) precipitation, (e) rainfall and (f) snowfall. Temperature trends are shown as absolute values (°C) and precipitation, rain and snowfall trends are shown as percentage difference from their 1961–1990 mean.

precipitation conditions averaged over an extended period, usually 30 years (such as 1961–1990). These are used as a baseline from which to compare projected changes in climate. Climate change refers to trends or major shifts in climate over a long period of time; such as decades or centuries. Climate variability relates to changes in temperatures and precipitation ranging from months to multi-decadal oscillations. As a result of climate variability, colder than average years regularly occur in spite of long term warming trends. Two important patterns of climate variability in Prince George include the El Niño Southern Oscillation (ENSO) which has cool-wet and warm-dry phases that typically persist for up to 18 months each, and the Pacific Decadal Oscillation (PDO) that has warm and cool phases that can each persist for up to 30 years (Moore et al., 2010). Examining past seasons and years that have been affected by climate variability (such as a winter during a warm ENSO phase) can provide valuable insight into how future climate change will affect a region.

Maps showing the climate normals in the vicinity of Prince George were presented to demonstrate the range in climate conditions in the region. Next, long term climate trends were presented using data from Environment Canada's Adjusted Historical Canadian Climate Dataset (AHCCD), which have been reviewed and adjusted to reduce the influence of station movements or changes in measurement techniques on the data (Mekis and Hogg, 1999; Vincent and Gullet, 1999). The long term trends show how climate has been changing in the area. Between 1918 and 2006, mean air temperature increased by 1.3 °C per century. Minimum (night-time low) temperatures increased at a faster rate at 2.3 °C per century, while maximum (day-time high) temperatures only increased at 0.2 °C per century over this time period (see Fig. 1). Increases were significant at the 5% significance level, except for maximum temperatures. Rates of warming continued to increase throughout the century, and the mean temperature warming trend from 1971 to 2006 was equivalent to a rate of 4.6 °C per century. Trends for the shorter time period are likely influenced by both increasing human-caused global warming towards the end of the century, as well as the warm phase of the PDO natural variability cycle from 1976 to ~2000 (Salinger, 2005). Total precipitation, snowfall and rainfall increased by 9%, 9% and 17% between 1918 and 2006, respectively (Fig. 1). Similar increases in precipitation have been found for many areas in BC since the early 1900s (Rodenhuis et al., 2009). Trends became negative for snowfall but positive for rainfall since the middle of the 20th century, which illustrates that a greater proportion of precipitation has been falling as rain in recent decades. None of the precipitation trends were statistically significant.

Global climate models (GCMs) are representations of the climate based on its biological, chemical and physical properties and are widely regarded as the best and most reliable tools to simulate future conditions (IPCC, 2007c). Projected changes in temperature and precipitation were presented in two forms. Box plots were used to show the range of projected changes from a large ensemble of GCMs (which have a horizontal resolution of approximately 300 km) for three time periods: 2011–2040 (2020s); 2041–2070 (2050s); and 2071–2100 (2080s) (Fig. 2). Maps were used to illustrate the spatial range in changes from a regional climate model (RCM)

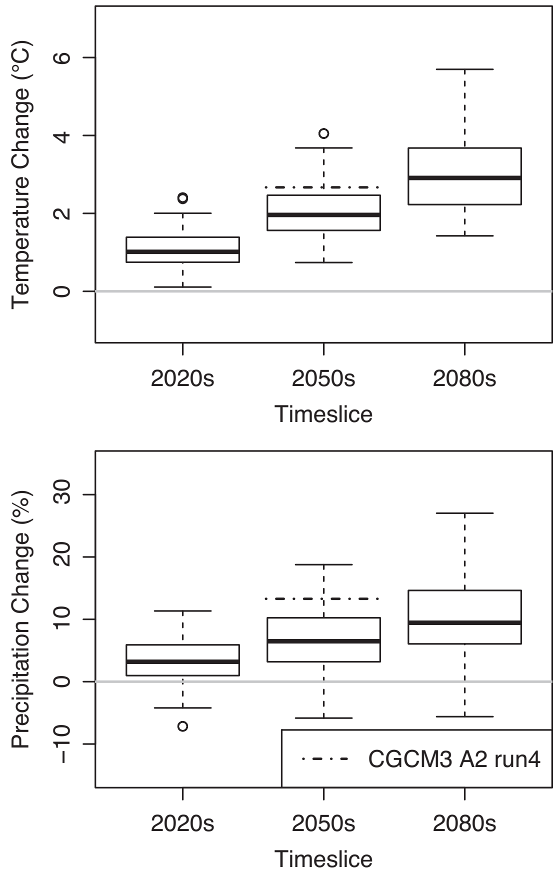

Fig. 2 – Box plots of GCM projected changes for the Prince George region in annual mean (a) air temperature and (b) precipitation as compared to the 1961–1990 model baseline based on an ensemble of 140 projections from 22 GCMs under the A2, A1B and B1 IPCC emissions scenarios. The thick line depicts the median, the top and bottom of the box the 75th and 25th percentiles, and the whiskers 1.5 times the inter-quartile range from the median. The° symbol indicates a value outside the whiskers. The dashed horizontal line indicates the GCM used in the RCM maps.

at high resolution (~45 km) as forced by one GCM at the boundary for the 2050s (Fig. 3). The RCM maps are helpful to illustrate spatial variations and the influences of factors such as elevation and land surface characteristics on projected climate change. The suite of GCM projections for three time periods complements the RCM maps by showing the range of uncertainty present in a large number of simulations. The uncertainty in GCM projections arises from differences such as the physics of individual GCMs, natural climate variability and different GHG emissions scenarios. Differences in GHG emissions scenarios are not a large contributor to projection uncertainty until after the 2050s (Rodenhuis et al., 2009). Box plots are based on ensembles of 140 GCM projections from 22 different GCMs, each run (in some cases several times) under the A2, A1B and B1 emissions scenarios (IPCC, 2007a). These were presented as annual and seasonal values to demonstrate projected changes in seasonality of climate. Participants were instructed to focus on the range of projections for the 2050s

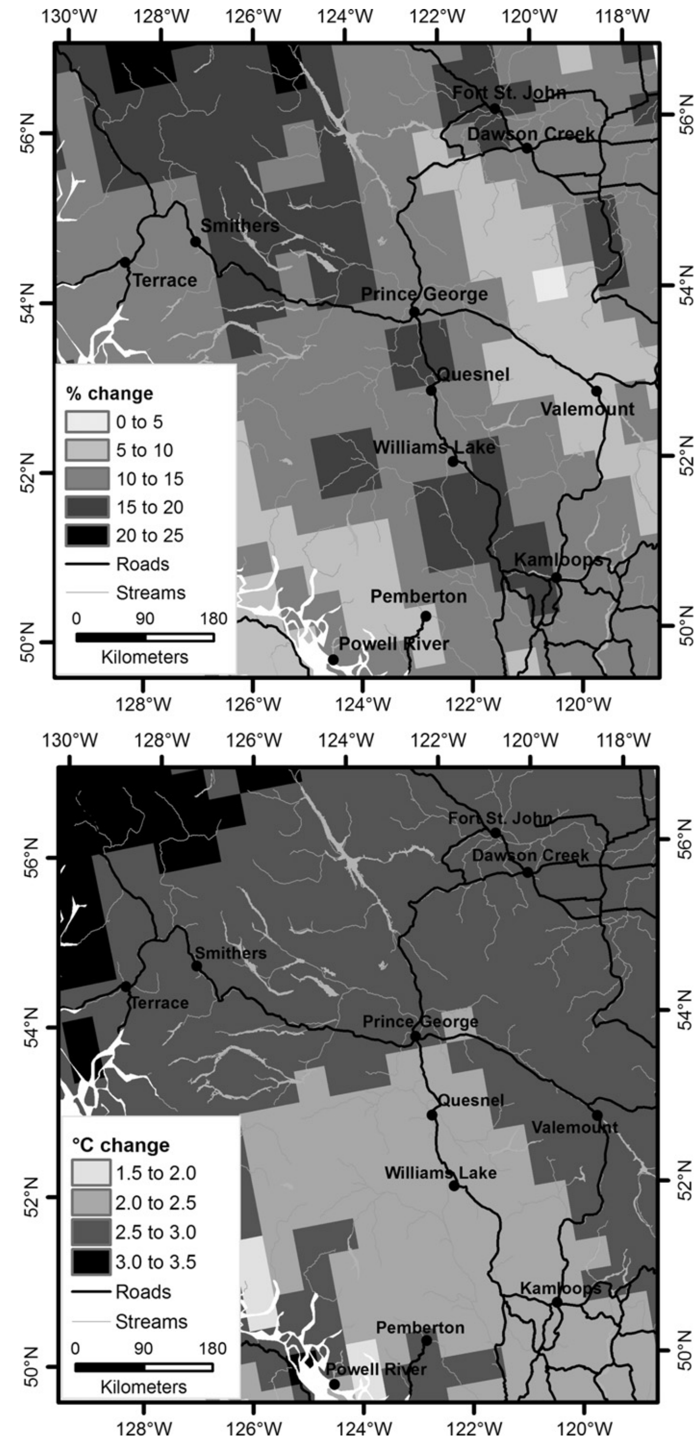

Fig. 3 – Maps of 2050s projected annual anomaly from the 1961–1990 baseline for (a) mean temperature and (b) precipitation in the Prince George region, based on one RCM (CRCM4) forced with one GCM (CGCM3 run 4 following the A2 emissions scenario). For context, see Fig. 2 for position of the driving GCM versus other projections. Source: Ouranos Consortium.

when evaluating impacts as this is an appropriate horizon for most planning processes.

Annual temperatures in Prince George are projected to increase by 2.0 °C by the middle of the century, based on the median of 140 projections. The mid-range (25th to 75th percentiles) of the projections was 1.6–2.5 °C. Annual precipitation is projected to increase by 6% based on the median with the mid-range from 3% to 10%. Precipitation increases of 8% are projected for winter and decreases of 1% are projected for summer based on the median. Therefore, conditions are projected to be warmer and primarily wetter in winter and annually, but could be drier or wetter in summer. However, in both seasons, projected precipitation changes vary from decreases to increases depending on the GCM and scenario.

Further details are provided in the report "Climate Change in Prince George: Summary of Past Trends and Future Projections" (Picketts et al., 2009a).

3.1.2. *Organizing feedback*

Feedback for each of the impacts from the master list was organized by having participants individually fill out a spreadsheet or 'matrix'. A representation of the matrix is included as Fig. 4.

3.1.3. *Plans for implementation*

The documents included in the matrix for participants to select from are plans commonly used in BC that could house adaptation strategies. (Local stakeholders will need to identify which plans are potentially suitable for housing adaptation in their communities.) A brief description of these plans follows:

- *Integrated Community Sustainability Plans (ICSPs)*: Umbrella documents focusing on long term environmental, economic and social sustainability.
- *Official Community Plans (OCPs)*: Municipal land use and community development plans, with a five to 20 year horizon, which are implemented through bylaws.
- *Annual Provisional Financial Plans (Financial Plans):* Overviews of a City's capital and operating budget outlining expenditures and sources of funding for the year, and projections for upcoming years.
- *Subdivision and Development Bylaws (Bylaws):* Concise and enforceable public laws that regulate and require the provision of infrastructure works and services for development.
- *Asset Management Performance Measures (Asset Mgmt):* Strategies to allocate funds and resources to competing asset needs (such as lands, buildings and roads), and to understand the condition of assets.

Participants were invited to provide more information regarding implementation for each impact on the reverse-side of the matrix worksheet.

3.2. *Prince George workshop results*

The workshop introduction served to clarify the focus on adaptation and, as a result, discussion did not deviate to mitigation or other areas of focus. The climate information helped workshop attendees grasp what the major trends in the region are, what types of changes to Prince George's climate are expected and how significant these projected changes are in the context of historical variability and past trends. Having a climate information expert in attendance to present the data and answer the multitude of participant questions was very helpful.

The impacts that will affect Prince George, as identified by the individual focus groups, are outlined in Supplementary Table 1. Distilling the separate focus group outcomes into a

Prince George Climate Change Workshop Matrix

	RISK		SECTORS MOST SERIOUSLY EFFECTED (please check off only 5 sectors)																								IMPLEMENTATION					
			Administrative Services			Corporate Services					Development services				Operations				Community Services			Outside Agencies, Organizations, Groups					Where should this issue be addressed? - please indicate top priority					
Impact:	RISK: likelihood and timing (scale of 1 - 5: see chart 1)	RISK: consequence of inaction (scale of 1-5: see chart 2)	Real Estate & Bylaw Services	Police, Fire & Rescue Services	Municipal emergency & Response	Financial Services	Human Resources	Risk and Benefits	Fleet and Supply Services	IT Services and GIS	Current Planning	Long Range Planning	Building Inspection	Environmental Services	Parks and Trails	Solid Waste Services	Utilities	Transportation	Civic Facilities	Community Services	Social Policy	Federal	Provincial	First Nations	Other Local Government	Other Organizations (please specify)	ICSP	OCP	Annual Provisional Financial Plan	Standards Bylaw	Asset Mgmnt-Performance Measures	Other (please specify)
1																																
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CITY OF PRINCE GEORGE

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Chart 1: Risk Scale - likelihood and timing

score	likelihood	Explanation
5	occuring now	already happening
4	very likely	likely to happen in next 10 yrs
3	likely	may happen in next 20 yrs
2	unlikely	may or may not happen
1	very unlikely	will not effect us

Chart 2: Risk scale: consequence

score	consequence	Explanation
5	catastrophic	major consequences to human life
4	major	risk to health and life, v. expensive (>$10mil)
3	medium	risk to health, expensive ($2-10mil)
2	low	low risk to health, mid expense ($1-2 mil)
1	minimal	minimal costs

Fig. 4 – Matrix for organizing participant feedback.

single list of local impact priorities proved more difficult than expected. A comprehensive list was necessary for the final steps of the workshop to be effective; therefore a draft was presented back to the entire group and put up for discussion. Through discussion with participants some impacts were changed (for example the infrastructure category was separated into storm-water, utilities and transport impacts) and a new topic was added (erosion and landslides). Three priorities identified were deemed unsuitable for the master list. These were land use impacts and impacts on policy (both considered responses rather than impacts), and economic impacts (considered too broad as it encompasses all impacts).

Participants were able to perform the risk evaluation exercise and identify sectors to address the outcome without difficulty, but many had difficulty selecting a single document where implementation should occur. The master list of impacts, average (mean) values for workshop participants' perceptions of the two risk types, standard deviations and the average risk values (product of mean consequence and likelihood) are shown in Table 1. The City sector and plan for implementation most often selected are also included. Results are from the 28 participants who completed the full matrix, and are organized by total risk value.

Some participants provided comments on implementation (on the reverse-side of the matrix) which were transcribed for future use. Due to the tight timeline many people left this section blank. The final plenary discussion solicited feedback from the participants about the workshop. It also was an ideal opportunity to inform participants of future adaptation research in Prince George, and to gauge interest regarding ongoing participation in adaptation initiatives.

3.3. *Workshop framework*

Based on the experiences with Prince George, a six step framework is proposed in Table 2 that communities can apply to outline an adaptation strategy within a single day. The time allocated for each step will depend primarily on the experience participants have related to adaptation. Steps of the workshop should be modified to produce results which are most useful to the community.

4. Discussion and conclusions

The City adaptation workshop was effective in achieving both intended objectives: (1) increasing local knowledge and awareness; and (2) identifying priority impacts for Prince George. Participants unanimously supported the outcomes of the event, and indicated that they would remain engaged as the research moved towards implementation. Since the event many participants have offered their expertise and experience towards continued local adaptation planning, an adaptation strategy has been finalized (Picketts et al., 2009b) and measures have been incorporated in the City's ICSP and OCP. Prince George is, and will continue to be, affected by the impacts of climate change. However, the City has a high adaptive capacity as well as potential to experience some tangible benefits from warmer temperatures, such as a longer growing season (Walker and Sydneysmith, 2008). Adaptation

Table 1 – Results from the adaptation strategy visioning exercise ($n = 28$).

Top priorities identified by participants	Risk					City sector to address impact	Plan for implementation
	Perception of risk: likelihood and timing		Perception of risk: consequence of inaction		Average risk: product of means		
	Mean	Std. dev.	Mean	Std. dev.			
Increased forest fires	3.8	1.0	4.0	0.6	15.2	Police, fire and rescue	ICSP
Increased flooding	3.9	1.3	3.4	1.0	13.2	Emergency and response	ICSP
Extreme weather/emergency response	3.7	1.3	3.2	1.1	11.8	Emergency and response	Financial plan
Threats to water quality and quantity	3.1	1.1	3.7	0.9	11.4	Utilities	ICSP
Increased freeze/thaw on transport	4.1	1.4	2.5	0.7	10.3	Transportation	Asset mgmt
Erosion and landslides	3.4	1.1	3.0	0.8	10.2	Long range planning	OCP
Stresses on storm-water infrastructure	3.6	1.2	2.7	0.8	9.7	Utilities	Asset mgmt
Stresses on utilities infrastructure	3.2	0.8	2.9	0.9	9.3	Utilities	Asset mgmt
Other stresses on transport infrastructure	3.7	1.4	2.3	0.8	8.5	Transportation	Financial plan
Extreme weather limiting transport	3.0	1.0	2.8	1.0	8.4	Transportation	ICSP
More residents and business opportunity	3.4	1.0	1.6	1.0	5.4	Long range planning	OCP
Increased agricultural capacity	2.6	0.6	1.4	0.6	3.6	Long range planning	OCP

Table 2 – Adaptation workshop framework.

Step	Purpose	Information presented	Time allocation
1. Introduction	Clarify workshop focus; overview activities; inform participants of their key role in outlining strategy	Definition and differentiation between adaptation and mitigation; explanation of participants' role as experts with local knowledge	15 min to 1 h[a]
2. Under-standing changes in the climate	Provide overview of past changes and future temperature and precipitation projections in the region	Past climate trends and future scenarios (preferably downscaled and presented by climate information specialist)	1–2 h[b]
3. Identifying local impacts	Link climate projections with actual impacts in community (can be done in focus groups or as one larger group)	None, but requires careful facilitation by persons familiar with adaptation and the community	~1 h (depends on group size)
4. List of local impacts	Combine outcomes of step 3 into a single list (if necessary)	Outcomes combined by organizers and presented to plenary for discussion and finalization	~45 min[b]
5. Visioning an adaptation strategy	Prioritize impacts and recommend implementation actions	Framework for determining risks; potential sectors to address impacts; documents where implementation may be outlined	~90 min
6. Final discussion, next steps	Encourage continued engagement in adaptation planning and solicit feedback on event	Feedback should guide further local adaptation	~30 min[c]

[a] For neophyte communities a separate capacity building event may be preferable.
[b] Ample time for discussion should be allocated.
[c] Can encourage discussion to continue after formal workshop end.

planning will lead to a more prepared and resilient community, and help local residents maintain their quality of life despite expected and unexpected changes in the climate.

Although concerted efforts were made to present the information concisely, a point articulated by several participants in the concluding discussion was that climate scenarios have to be presented in a simpler manner for local practitioners and members of the public to understand the content. Communicating future scenarios is an ongoing challenge as it is important to convey the considerable uncertainties and limitations with climate projections while still being brief. Although there have been great improvements in climate projections and they will continue to improve in the future, uncertainties will always exist. However there are additional and greater sources of future uncertainty, such as technological and cultural unknowns. Therefore a lack of certainty in projections should not be a barrier to adaptation action (Adger et al., 2009).

Subsequent to the workshop, PCIC has created a tool (www.Plan2Adapt.ca) that provides an overview of climate data and future projections for communities in BC. The tool presents more simplified information than is presented here. Communities in BC should be able to proceed with adaptation planning using this information, which is now freely available to them. Universities, governments and climate modelling groups should endeavour to make climate information easily accessible and clearly communicated to communities to facilitate adaptation planning and implementation.

Some of the priorities described by focus groups (see Supplementary Table 1) were not suitable for inclusion in the final list. However, unanticipated responses help illustrate that climate impacts are not simply environmental in nature, and will affect the social, cultural and economic wellbeing of communities (Juhola and Westerhoff, 2011). Forest fires and flooding were clearly the top ranked priorities, which is expected due to the City's location and surroundings. Extreme weather/emergency response overlaps with the top priorities and explicitly targets Municipal Emergency and Response as a sector that needs to be prepared for climate change. Transportation impacts were described in three separate categories, which implies that it is a very high priority.

An advantage of the risk-based approach is that participants who envision greater impacts tend to rank 'consequence' higher than their peers and 'likelihood' lower, and vice versa. Thus, averaging and multiplying the two factors gives a good general indication of risk, even if standard deviations are large. However, the large standard deviations and small variability among most 'average risk' values illustrate that the order of impacts displayed in Table 1 is a guide for future action, not a definitive roadmap. Communities that engage in this exercise must be prepared to re-evaluate priorities in response to changing conditions and information. Snover et al. (2007) recommend against ranking impacts, rather categorizing them into general levels of risk to allow other factors – such as actions underway, funding opportunities and changing technologies – to influence how implementation proceeds. However, a list of ranked priorities can be helpful for communities as they move towards implementation, if it is clearly communicated that the order is not prescriptive and can be changed.

One key shortcoming of the study's risk framework is that it did not properly account for positive impacts that may occur as a result of climate change. Therefore it is important to reconsider impacts which were not ranked highly, such as ''increased agricultural capacity'' and ''more residents and business opportunities'', independently to gain a better understanding of their priority in Prince George. For future workshops, organizers may consider expanding the ''consequence of inaction'' component of the risk scale to include positive consequences if action is taken. The risk framework also does not properly account for less certain or well-defined impacts such as health effects. It may also be necessary to examine other impacts not closely related to human safety and finances, which may not have been identified in the workshop. For example, the City of Prince George has recently indicated that ecosystem impacts should be examined in more detail, even though it was not identified as a priority in the workshop.

The sectors most commonly identified to address impact priorities in Prince George were: utilities; long range planning; transportation; and police, fire and rescue services. Therefore planners, engineers and other city staff working in and with these sectors should be aware of climate change adaptation and take an active role in preparing strategies to address impacts. The ICSP was the top plan noted for implementation, and the OCP, asset management plan and financial plan were also identified. These results, as well as the trouble participants had selecting just one plan for many impacts, illustrate that climate change will impact many facets of City planning and operations, and that adaptation must be pursued through multiple avenues. Plans with an integrated focus, long term time frame and consideration of environmental, social and economic priorities, such as ICSPs, are well suited to house adaptation strategies. Economic considerations will become extremely important as communities progress towards implementation.

The success of the workshop in Prince George was related to previous adaptation work that had occurred in the City, as well as local exposure to impacts. These experiences increased local capacity on adaptation, which allowed for a relatively brief introduction to the topic and focused discussion throughout the day. Communities with less capacity and experience will have to dedicate more time to background information, may require more guidance and facilitation throughout the day,[1] and may need more than a single day to achieve the desired objectives. (Multiple events would also allow more time for participant reflection.) Existing awareness in Prince George also led to a degree of local interest that resulted in an excellent turnout of engaged senior staff and stakeholders. Communities that have not encountered local impacts or begun adaptation planning may have more difficulty generating interest in the topic. A recurring comment in the final discussion session was that the general public must be consulted in the process if an adaptation strategy is to be successful. Since the workshop researchers have sought input from the community about their opinions on impact priorities. It is valuable to incorporate the results of multiple exercises to add validity and comprehensiveness to the research (Morgan, 2006).

The workshop serves as a tool which communities can learn from and build on to increase local capacity and outline adaptation priorities. Ambitious objectives were achieved in a short time frame with minimal resources by distilling the general steps of existing guides into brief, directed exercises that provided usable outputs. However, active facilitation is required to keep the workshop on time and the participants focused on adaptation. The short time frame allows for involvement by stakeholders who would not be able to participate in a longer exercise or ongoing committee. Using this framework, key community decision-makers can gain a better understanding of climate change and impacts, apply their local knowledge to inform adaptation strategies and become champions of adaptation.

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Appendix A. Risk methodology

To ensure that the methodology was robust the risk criteria were compared to criteria outlined by the IPCC (2007b) before the workshop. The IPCC criteria are:

- likelihood
- timing
- magnitude
- vulnerability
- distribution
- potential for adaptation
- persistence and reversibility

The risk framework used for the workshop closely aligns with the IPCC criteria. ''Likelihood'' and ''timing'' are encompassed in one of the workshop criterion of risk and ''magnitude'' and ''vulnerability'' in the other. The ''distribution'' criterion was not relevant because this study focused on a specific area. ''Potential for adaptation'' was not considered due to the time constraints and the consensus among organizers that Prince George has the capacity to address most changes it will face. ''Persistence and reversibility'' was not included as there was insufficient time to discuss how long impacts would remain or if they would be

[1] As an example of a more directed exercise, the Columbia Basin Trust is developing a tool for communities in south-eastern BC that provides regional impacts and adaptation measures for participants to select from (M. Laurie, personal communication, 16 May 2011).

permanent. This is also less relevant to communities, as irreversible and persistent climate impacts (such as extinctions, losses of ice sheets, losses of unique cultures and permanent drought conditions) do not usually pertain to City operations.

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.envsci.2011.12.011.

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