Knowledge Mobilization and Decision Support

Patricia Gober

Integrated Modelling Program for Canada Workshop: July 18-19, Saskatoon, SK

Rationale for IMPC—key questions

1) How will **climate change** affect the quantity/quality of Canada's water supplies, the risks from extreme events, the health of terrestrial and aquatic ecosystems, and the safety of communities?

2) What **adaptation/management strategies** are required to strengthen resilience to the anticipated changes and cope with new hydro-climatic regimes?

3) How can Canada strategically **balance the water needs of diverse stakeholders** at different levels--from local to national to address social, economic, and environmental challenges

4) How can Canadian water governance be improved to **overcome shared jurisdictional challenges** so that all orders of government (provincial, local, federal) better work together?

5) How will Canada address challenges to water resource protection and development that predominantly affect **Indigenous Peoples** across Canada's rural and northern regions?

Themes C and D

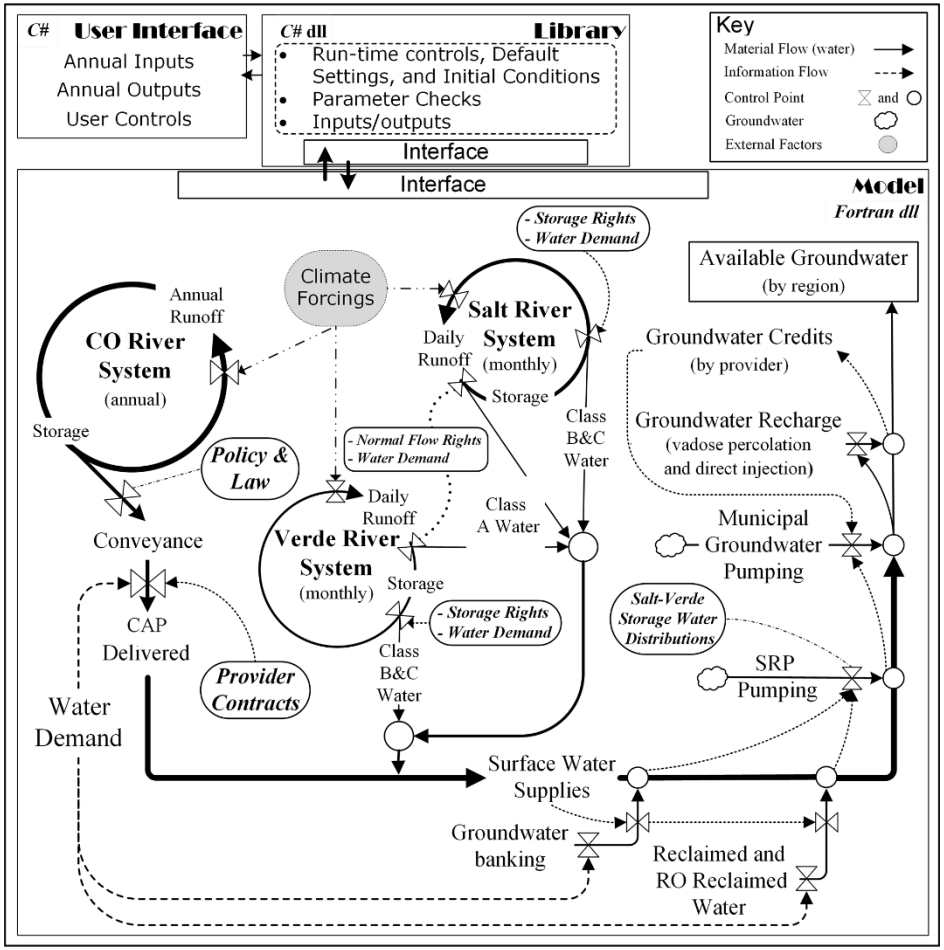
- Integrate users into problem framing
- Develop decision support systems
- Visualization
- Engage users in scenario planning
- Use models for exploratory purposes
- Develop new tools for communication of risk and uncertainty
- Use vulnerability studies to inform management, policy, and governance

Decision Center for a Desert City

Background:

- NSF's Decision Making Under Uncertainty (DMUU) Initiative
- Reframe climate change question to focus on decision making
- Create "what if" scenarios under conditions of policy change
- Boundary organization

WaterSim 5


C# User Interface
Annual Inputs
Annual Outputs
User Controls
C# dll Library
Run-time controls, Default Settings, and Initial Conditions
Parameter Checks
Inputs/outputs
Interface
Interface
Key
Material Flow (water)
Information Flow
Control Point and
Groundwater
External Factors
Model
Fortran dll
- Storage Rights
- Water Demand
Available Groundwater
(by region)
Climate Forcings
Annual Runoff
CO River System
(annual)
Storage
Salt River System
(monthly)
Daily Runoff
Storage
Class B&C Water
Groundwater Credits
(by provider)
Groundwater Recharge
(vadose percolation and direct injection)
Policy & Law
- Normal Flow Rights
- Water Demand
Daily Runoff
Class A Water
Verde River System
(monthly)
Storage
Conveyance
Municipal Groundwater Pumping
CAP Delivered
- Storage Rights
- Water Demand
Salt-Verde Storage Water Distributions
Provider Contracts
Class B&C Water
SRP Pumping
Water Demand
Surface Water Supplies
Groundwater banking
Reclaimed and RO Reclaimed Water

WaterSim 5

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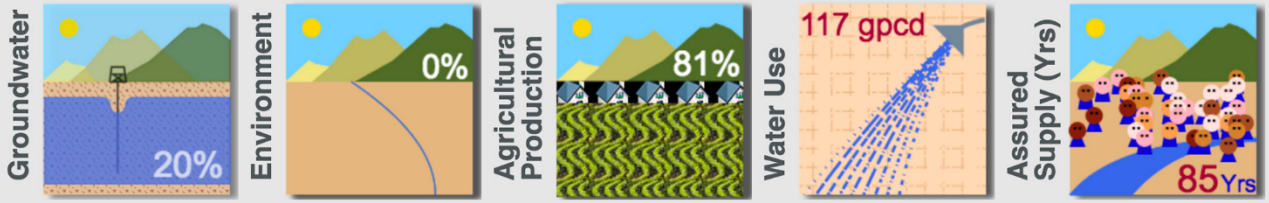
Global Institute for Water Security
USASK.CA/WATER

Sustainability Indicators



Policy Choices

Wastewater Reclaimed : %

0	25	50	75	100	19

Farm Water Used by Cities : %

0	25	50	75	100	30

Water For the CO Delta : % of AZ Share

0	25	50	75	100	0

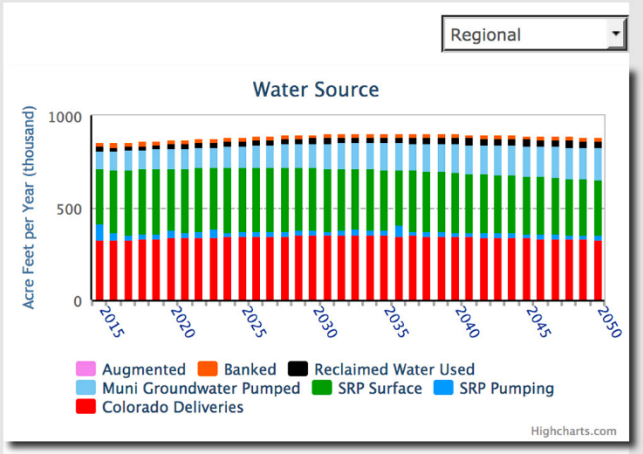
Per Capita Water Use : % of Forecasted

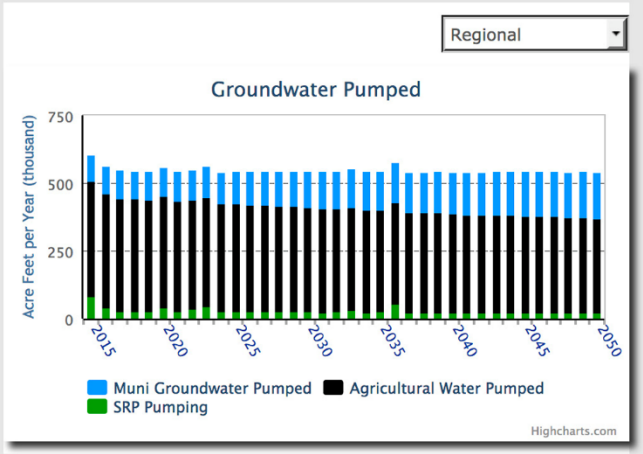
20	40	60	80	100	100

Population Growth : % of Forecasted

0	50	100	125	150	100

OUTPUTS: Supply | OUTPUTS: Demand | OUTPUTS: Reservoirs/Rivers | OUTPUTS: Sustainability | INPUTS: Climate/River Flows





Water Supply | Credits | Regional Aquifer | All

Run Model

ASU Decision Center for a Desert City, Arizona State University

WaterSim Phoenix

Decision Theater

UNIVERSITY OF SASKATCHEWAN
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Lessons Learned

- Shift water conversation from climate to human management
- Use models to simulate alternative futures emphasizing policy and human action
- Learn to manage uncertainty rather than be paralyzed by it
- Use modeling to reveal critical trade-offs between lifestyle and growth, infrastructure investment and risk reduction, etc.
- Co-production of knowledge
- Modelling is a process not a product

Scientists' Understanding of uncertainty

- Scientists conceptualize uncertainty in probabilistic terms using numerical and statistical methods.
- Scientists are rational actors who produce value-free knowledge.
- Widespread belief in the ability of science and technology to solve societal problems
- High standards for certainty of knowledge 5% or 1%
- Scientists identify the full set of possible outcomes for a given decision.

Policy makers' understanding of uncertainty

- Use a political model to characterize uncertainty based on specific circumstances and context
- May consider the political costs of being wrong
- Demand greater certainty for more consequential decisions.
- Wary of the potential for computer models to add more uncertainty to the decision process

Scenario Development

- Qualitative and quantitative process
- Surveys with decision makers
- Current-state appraisals and assessments
- Historical policy analysis
- Narrative analysis
- Review of existing plans, strategies and policy proposals
- Plausibility, i.e. there is sufficient evidence that the intervention could occur during the time frame for the simulations

Apropos to Non-Stationarity

- Non-stationarity means future climate conditions are outside the long-term historical range of variability.
- Traditional management based on existing problems, predicting a specific future, incorporating uncertainty derived from a historic range of variability, and planning to optimize water system based on expert recommendations.
- Anticipatory approaches incorporate
  a) Stakeholders' values and preferences
  b) Normative scenarios or visions of the future

Gober et al. 2016: Policy Variables

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Urban adaptation to mega-drought: Anticipatory water modeling, policy, and planning for the urban Southwest

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Water resources management
Sustainable urban development
WaterSim 5

ABSTRACT

This paper uses 'Medieval' drought conditions from the 12th Century to simulate the implications of severe and persistent drought for the future of water resource management in metropolitan Phoenix, one of the largest and fastest growing urban areas in the southwestern USA. WaterSim 5, an anticipatory water policy and planning model, was used to explore groundwater sustainability outcomes for mega-drought conditions across a range of policies, including population growth management, water conservation, water banking, direct reuse of RO reclaimed water, and water augmentation. Results revealed that business-as-usual population growth, per capita use trends, and management strategies are not sustainable over the long term, even without mega-drought conditions as years of available groundwater supply decline over the simulation period from 2000 to 2060. Adding mega-drought increases the decline in aquifer level and increases the variability in flows and uncertainty about future groundwater supplies. Simulations that combine drought management policies return the region to levels that are more sustainable. Results demonstrate the value of long-term planning and policy analysis for anticipating and adapting to environmental and societal change. Similar anticipatory exercises can be used to assess different suites of drought management policies in other cities facing uncertainty about future conditions.

1. Introduction

Climate change is expected to increase the frequency, intensity, and duration of drought in the southwestern United States in coming decades, and questions are being raised about the sustainability of the region's water resources (Cook, Ault, & Smerdon, 2015). General Circulation Models (GCMs) have been used as the basis for projecting future climatic and hydrological conditions under varying greenhouse gas concentration scenarios (Vörösmarty, Green, Salisbury, & Lammers, 2000; Kundzewicz et al. 2008; Arnell, 2004). There is, however, low confidence about the severity, seasonality, and spatial patterns of drought conditions and their implications for regional water supply when the GCMs are combined with regional climate and hydrological models (Wilby & Dessai, 2010). Wilby (2005) and Trenberth (2010) have warned that uncertainties associated with the GCMs are unlikely to be resolved in the short-to mid-term future because models vary in the way they treat complex climate processes, and there are trial-and-error effects associated with adding more variables and feedbacks to capture system dynamics.

Water managers need to make decisions about how to adapt to climate change before the scientific uncertainties of climate modeling and hydrological impact assessment are resolved. They face classic decision making under uncertainty (DMUU) conditions where stakeholders disagree about problem definition and the probability distributions that describe critical components of the system (e.g., future streamflow and climate, per capita water use, behavioral response to policy instruments). Traditional predict-and-plan efforts in water resources management using optimization models are ill-suited to DMUU problems (Gober, Kirkwood, Ellis, & Deitrick, 2010; Quay, 2010). DMUU strategies favor scenario building, exploration of a wide range of policy options, the search for robust policies that work well across a range of climate conditions, and efforts to preserve the flexibility to respond when the unexpected occurs (Lempert, Popper, & Bankes, 2003). Such strategies often use exploratory simulation models to

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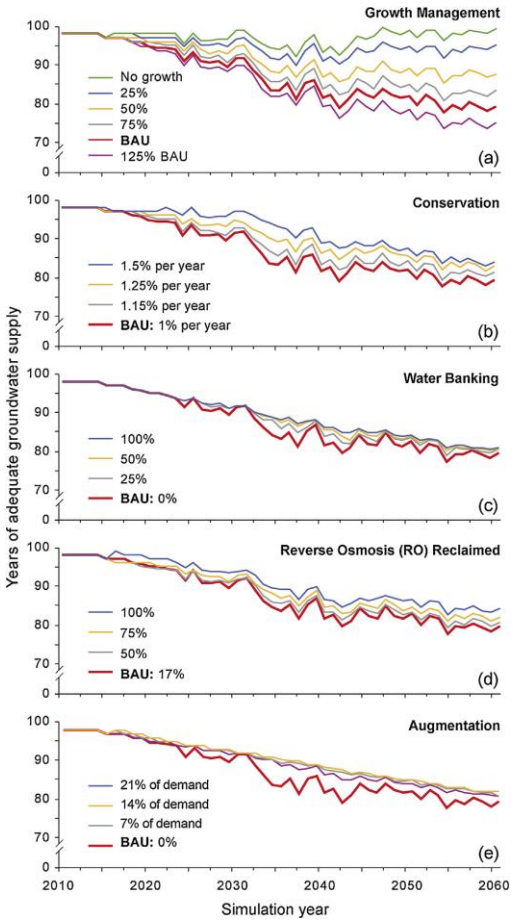
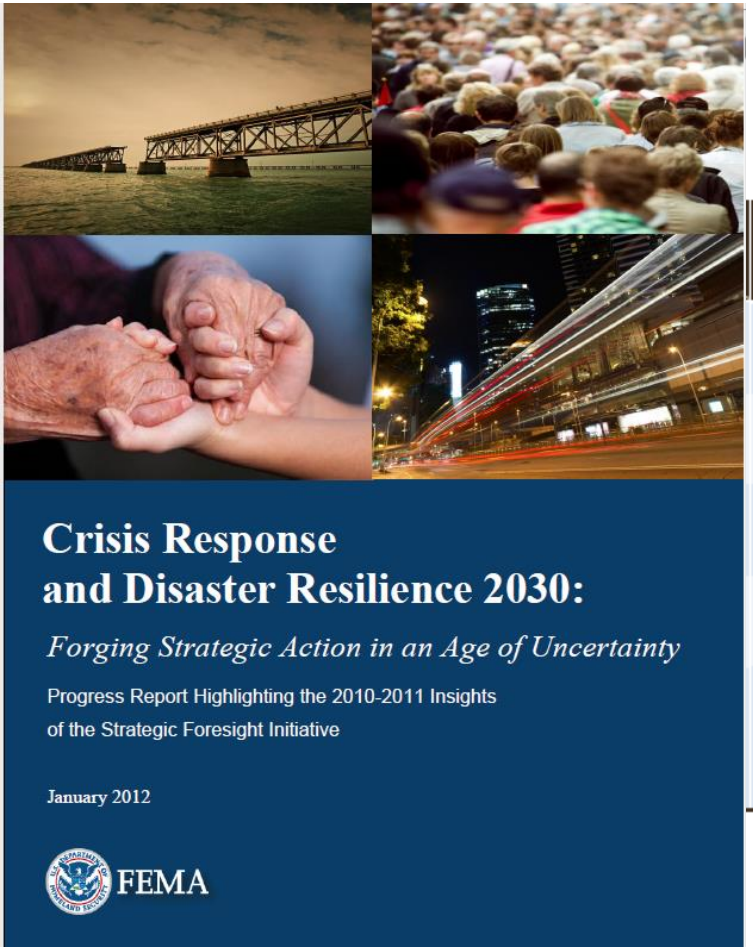
http://dx.doi.org/10.1016/j.scs.2016.05.001
2210-6707/



Scenario Development Around the World

FEMA 2012



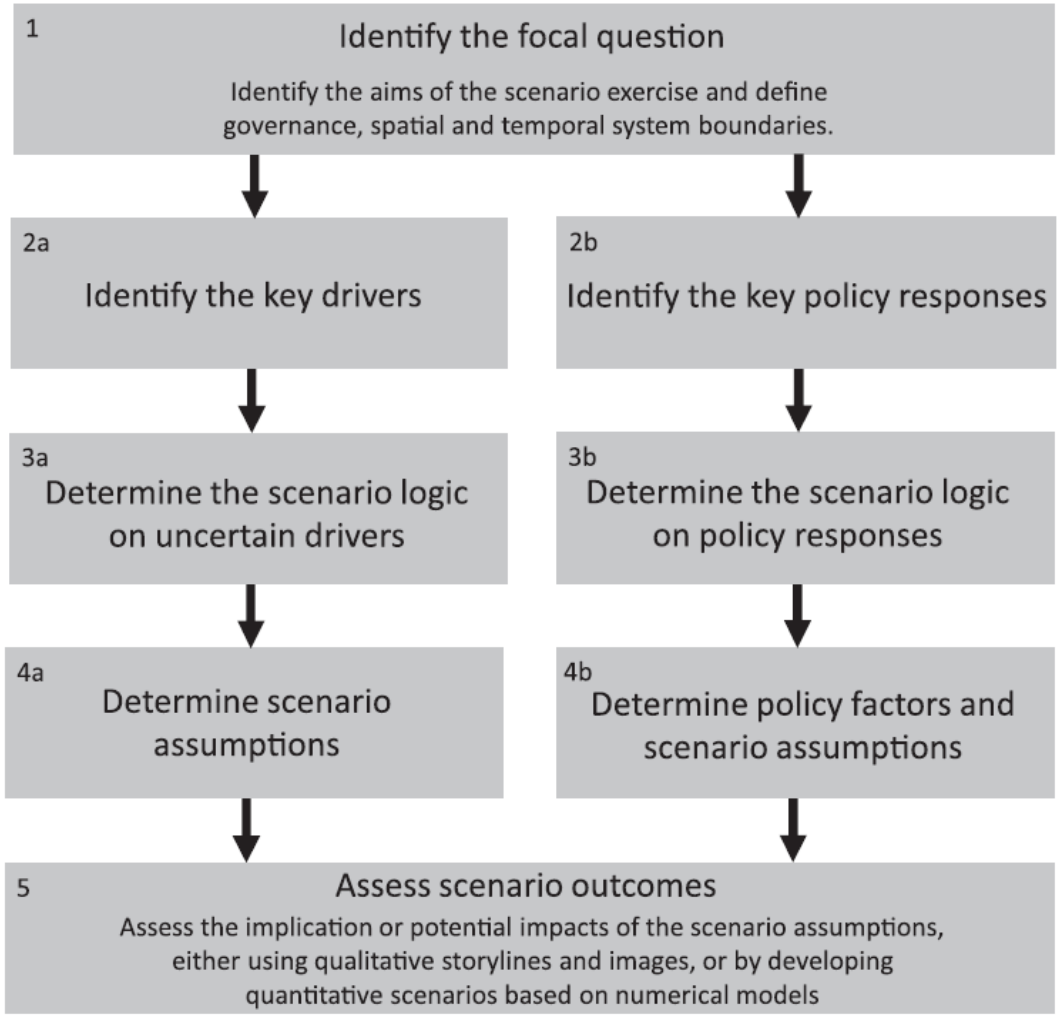
Select SFI Scenario Characteristics

(abbreviated list)

Quantum Leap	Bet on the Wrong Horse	Dragon vs Tiger	Treading Water	Dude, Where's My Sovereignty?
Strong, vibrant, dynamic	Lethargic, in and out of recessions	Strong rebound after a period of decline and	Worst since Great Depression	Lagging peer competitors
Extreme events more frequent	Stabilizing; climate change possibly reversed	Steady state trend in climate change	Worsening trend, with more extreme weather	More severe storms, droughts and flooding.
Bleeding-edge modernization underway	Mixed; transport lags global trends	Highly advanced, with embedded IT and security	Seriously degraded	General decline; pay-per-use is widespread
Relatively strong, but with pockets of distress	Rural areas hit by population shifts to urban areas	Recovering after massive federal bail-outs	Extreme fiscal vulnerability with paring of fed help	States very powerful but prospects vary
Climate change effects, technology in wrong hands	Cyber-security, chronic fiscal pressures	Potential for nuclear conflict abroad; complacency	Pandemics, poverty, limited public resources	Underfunded entitlements; foreign influence; weak federal leadership

FEMA, Department of Homeland Security. 2012. "Crisis Response and Disaster Resilience 2030: Forging Strategic Action in an Age of Uncertainty." Progress Report Highlighting the 2010-2011 Insights of the Strategic Foresight Initiative. Available on fema.gov.

Policy scoping and scenarios



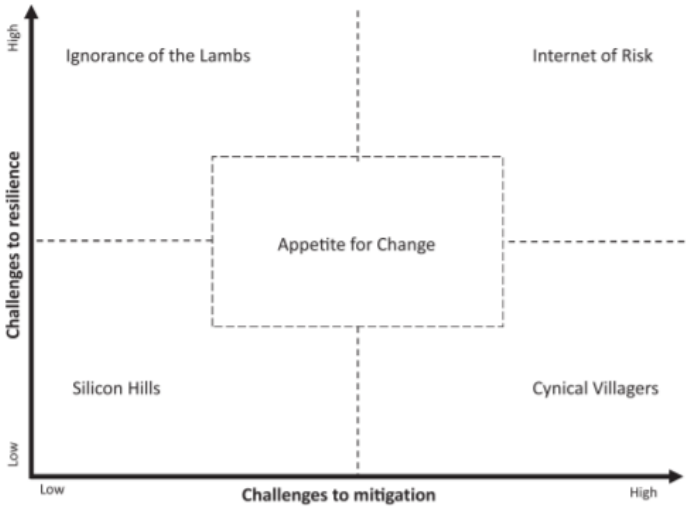


Fig. 4. Scenario framing and layout.

Invitational Drought Tournament 2014

This exercise focused on adaptive strategies to build resilience to drought impacts in the prairies. Involved interdisciplinary teams of stakeholders working together to achieve sustainable outcomes.

Hill et al. 2014. The Invitational Drought tournament: What is it and why is it a useful tool for drought preparedness and adaptation? Weather and Climate Extremes 3: 107-116

Who is doing what with water and why?

What people are proposing to do with water in the Nelson-Churchill Basin, either now or in the future, in terms of…

Water Supplies

- activities that address where water comes from, how water supplies are acquired, accessed and managed.

Water Delivery

- activities that entail distributing water to end users through natural and engineered systems that facilitate the use and consumption of water supplies.

Water Uses

- how people use, consume, and conserve water for various purposes.

Water Outflows

- activities that encompass the treatment of water after it is used (e.g. handling of sewage or effluent).

Water-Related Hazards and Vulnerability

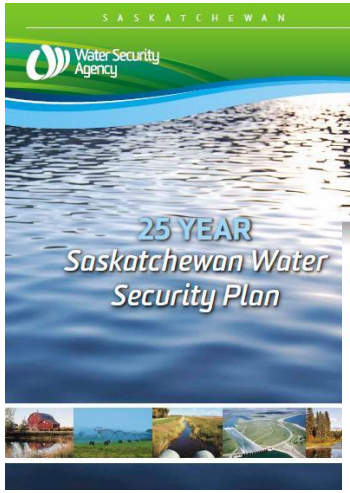
- activities that involve the protection of vulnerable water systems, safeguarding access to water functions and services, protection against water-related hazards like floods and drought.

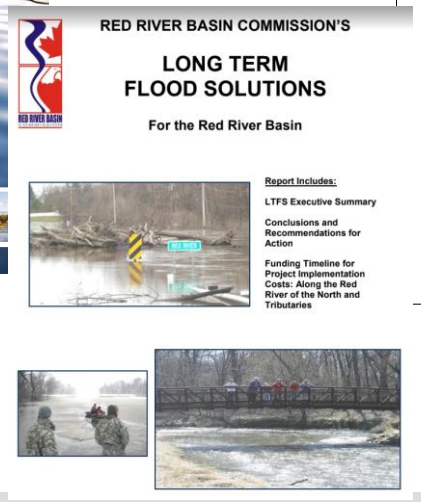
Cross-Cutting Activities

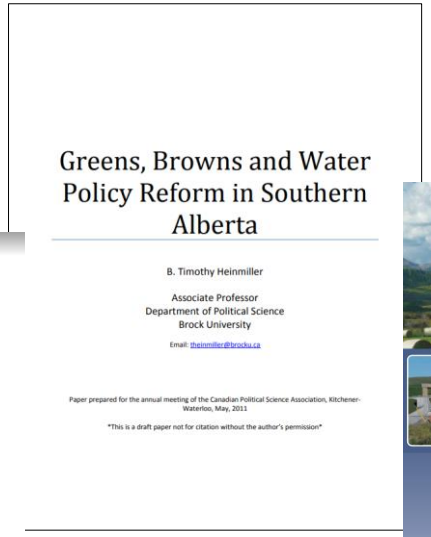
- activities that interact with and influence other activity domains (i.e. supplies, deliveries, uses and/or outflows). For example, this may include processes such as research and data collection, the nature of stakeholder engagement or policy-making.

Scenario Development in GWF

Source materials: existing water policy plans and proposals, stakeholder policy proposals and peer-reviewed published literature, as per White *et al.* (2015).






Greens, Browns and Water Policy Reform in Southern Alberta

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Brock University

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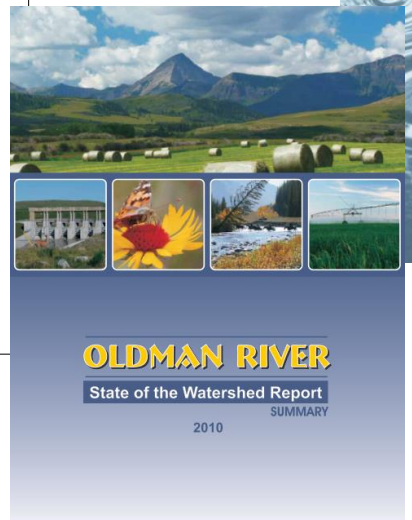
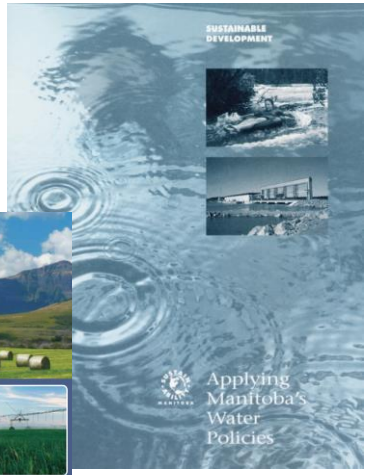
Paper prepared for the annual meeting of the Canadian Political Science Association, Kitchener-Waterloo, May, 2011

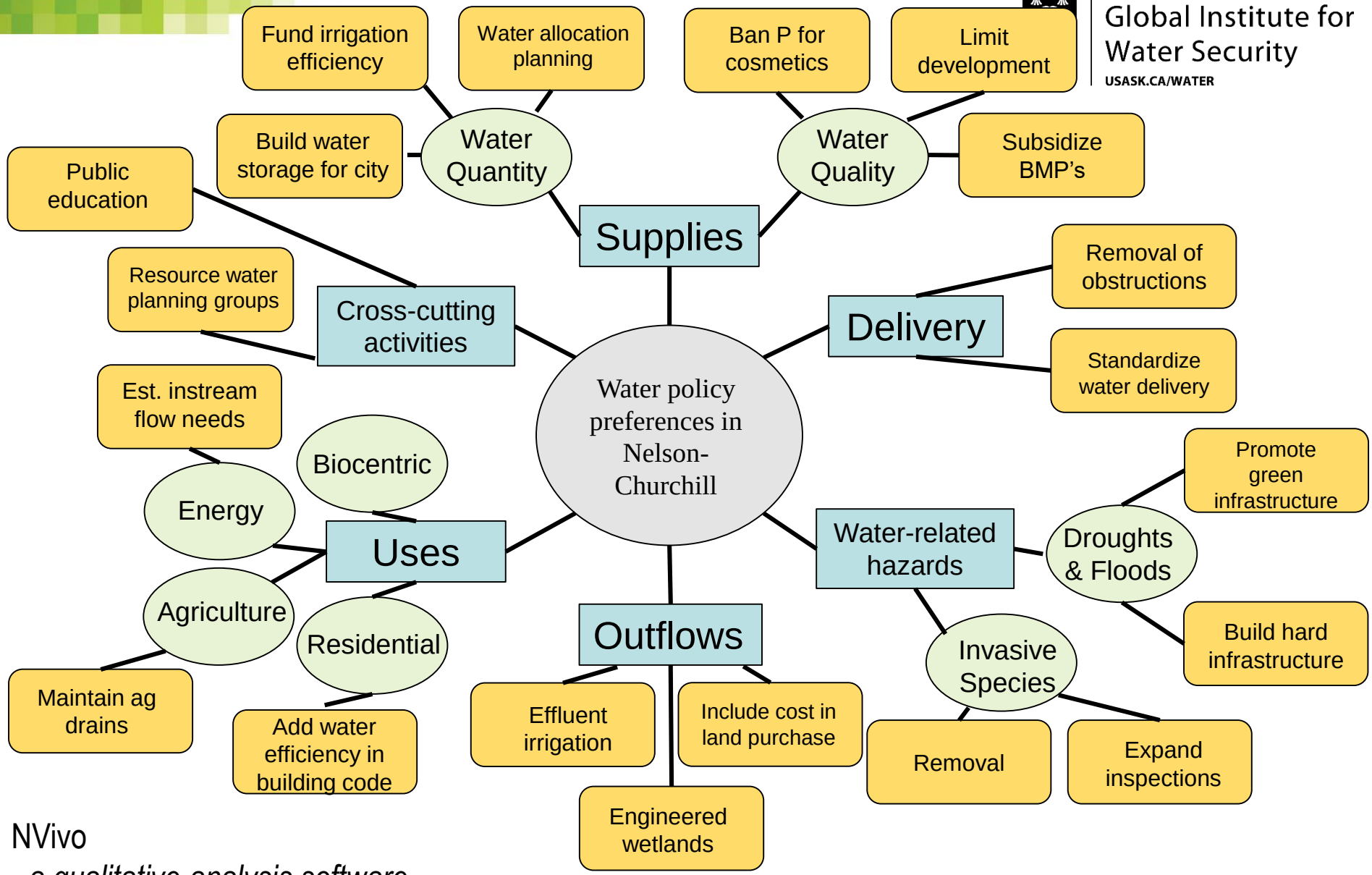
This is a draft paper not for citation without the author's permission





NVivo--qualitative data analysis tool

- Designed to work with textual data—how to understand themes, trends, and patterns
- Provides structure to unstructured data
- Transcribed interviews, focus groups, e-mail, published documents, meeting transcripts and reports, social media data
- Word frequency data, word cloud, word trees structured mind map
- Nodes are buckets of information from textual data—pull together from various kinds of data



NVivo
- a qualitative analysis software

Some ideas emerging so far

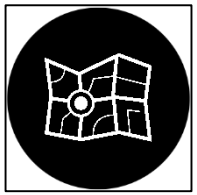

About the quality of water **outflows** and **supplies**:

Some stakeholders prefer **market-based** approaches.

- e.g. subsidize best management practices for agriculture, provide tax credits for riparian management, reducing financial disincentives to voluntary improvement of waste management practices.

Others, **regulatory-based** approaches.

- e.g. regulations to control pollution, establish predictable funding agreements for wastewater treatment, mandatory training for wastewater operators.



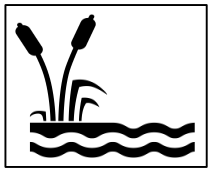
Some stakeholders want **constraints around growth and planning**.

- e.g. banning certain products (phosphate- and nitrogen-based fertilizers), limiting development in sensitive areas, de-growth.

About **water-related hazards** like droughts and floods:

Some stakeholders prefer **hard infrastructure** approaches such as

- e.g. building higher dykes, enhancing dams, floodway expansions, upstream water retention, water retention, remove beaver-related obstructions.



Others want to prioritize **promoting landscape resiliency**:

- e.g. protecting existing wetlands, restoring wetlands, preference for low-impact hydro.

Other stakeholders prefer **insurance and market-based approaches**:

- e.g. compensating flood victims, adjusting insurance premiums, providing incentives to improve irrigation efficiency.

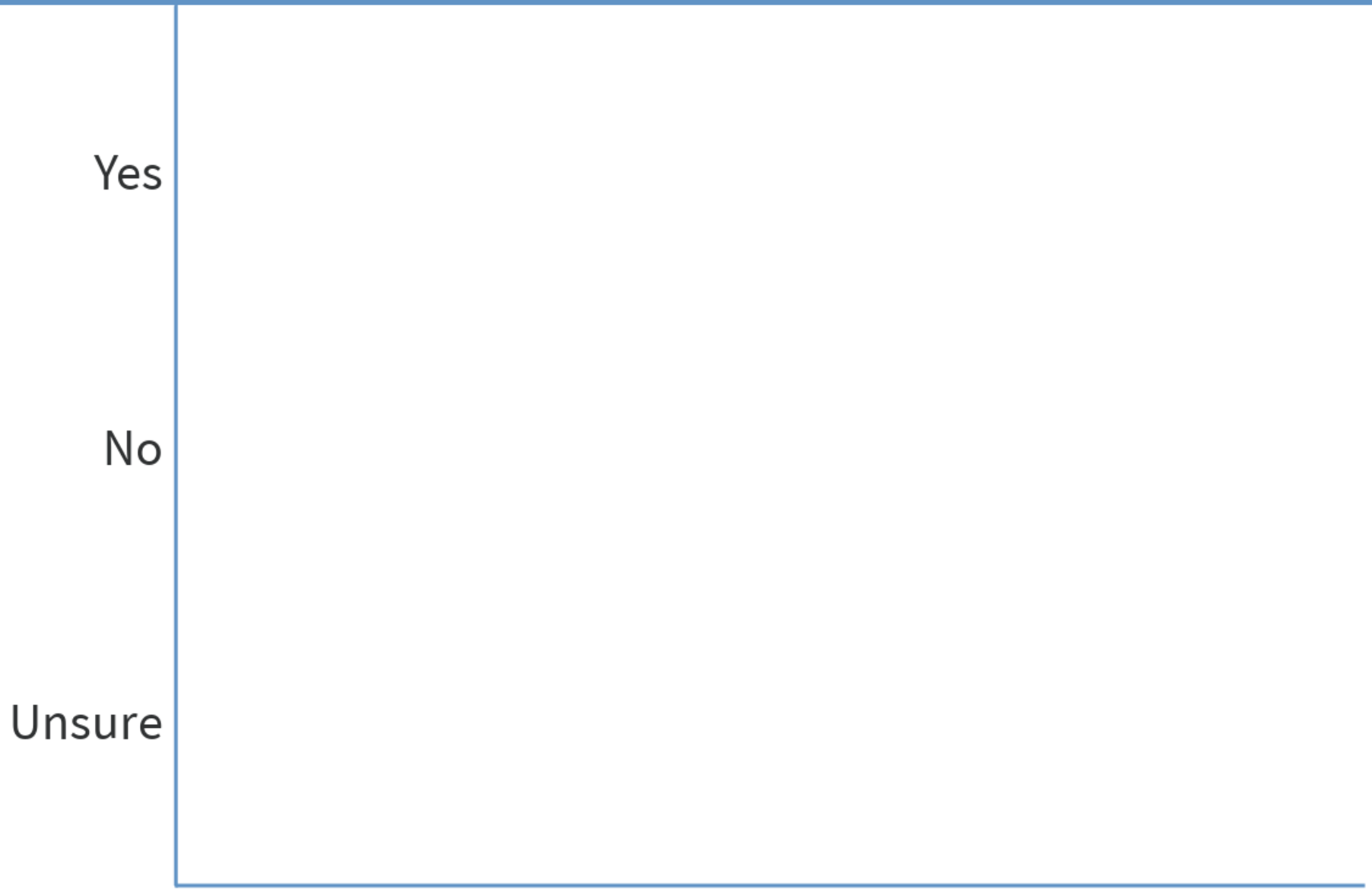
Attitudes and Policy Preferences: A Live Polling Exercise

To Join

By phone -> Text “IMPC” to 37607

By web -> PollEv.com/IMPC

Do you think the earth is warming?



Estimated % of adults who think earth is getting warmer / Pourcentage estimé de la population adulte qui perçoit un réchauffement

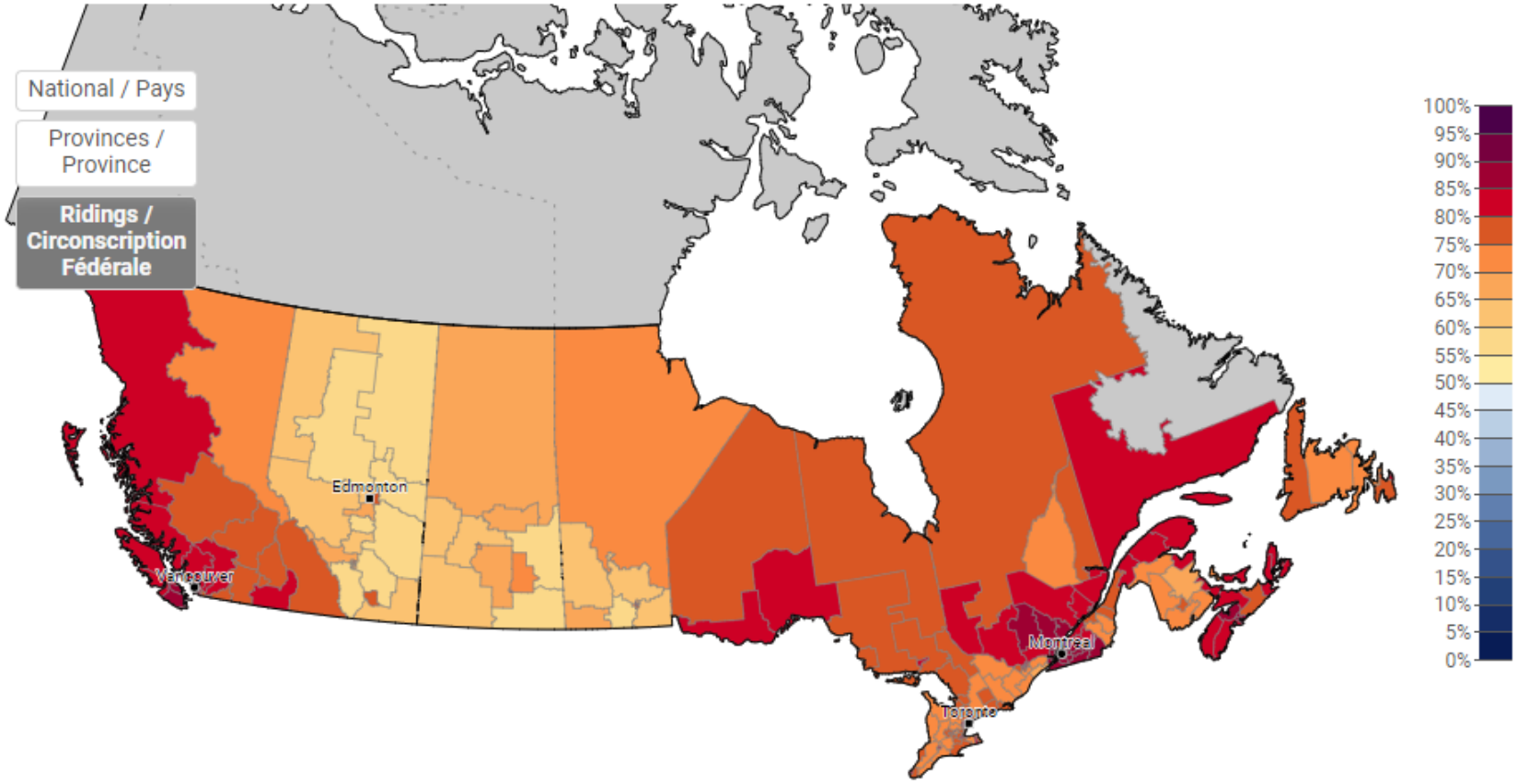
Display model output / Afficher les résultats de la modélisation:

Earth is getting warmer / La planète se réchauffe

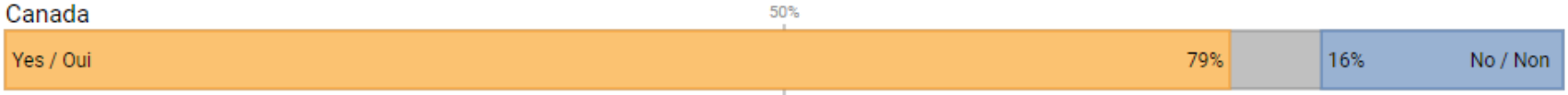
Permalink

Click on map to select geography, or / Cliquez sur la carte pour choisir une juridiction, ou:

Select a Riding / Sélectionnez une Circonscription Fédérale



Canada

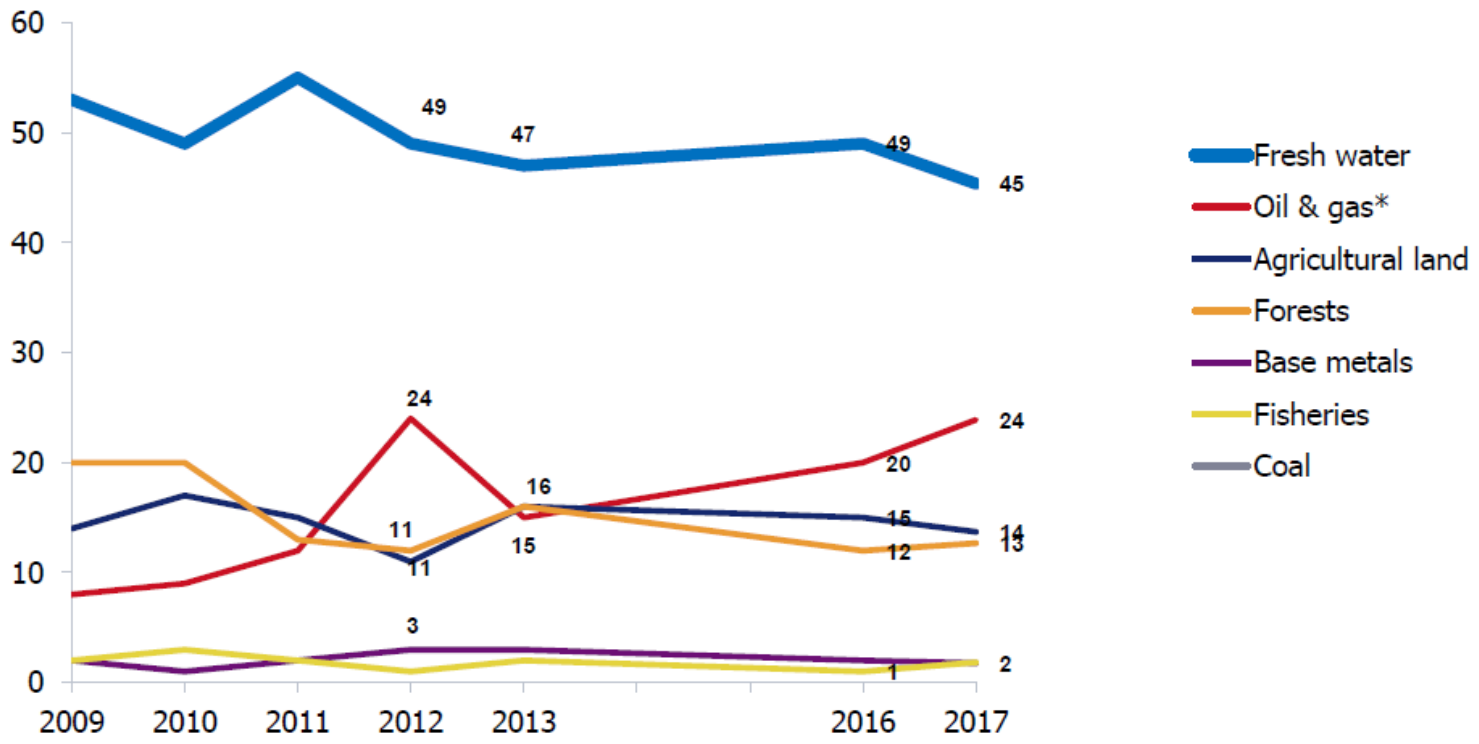


Mildenberger M, Howe P, Lachapelle E, Stokes L, Marlon J, Gravelle T. 2016. The Distribution of Climate Change Public Opinion in Canada. PLoS ONE 11(8): e0159774. https://doi.org/10.1371/journal.pone.0159774

Which of the following do you consider to be Canada's most important natural resource?

Canadians continue to consider fresh water to be Canada's most important natural resource

Canada's Most Important Natural Resource, 2009–2017



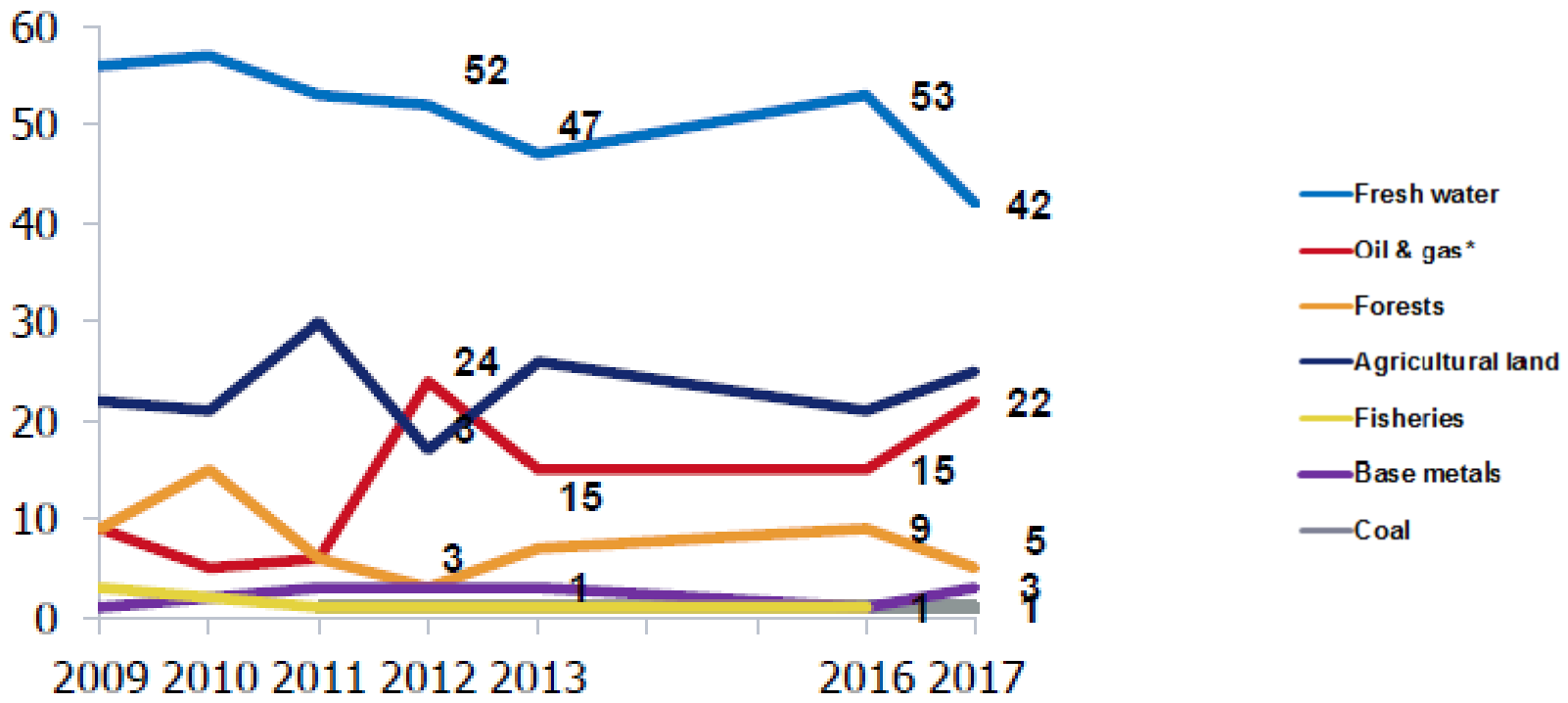
Base: All respondents 2017 *n*=2,017, 2016 *n*=2,194, 2013 *n*=2,282, 2012 *n*=2,428, 2011 *n*=2,066, 2010 *n*=2,022, 2009 *n*=2,165

*Modified from "oil" in 2013 to "oil & gas" in 2016

Q. Which of the following do you consider to be Canada's most important natural resource?

2017 RBC Canadian Water Attitudes Study

Prairies


60
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15
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1
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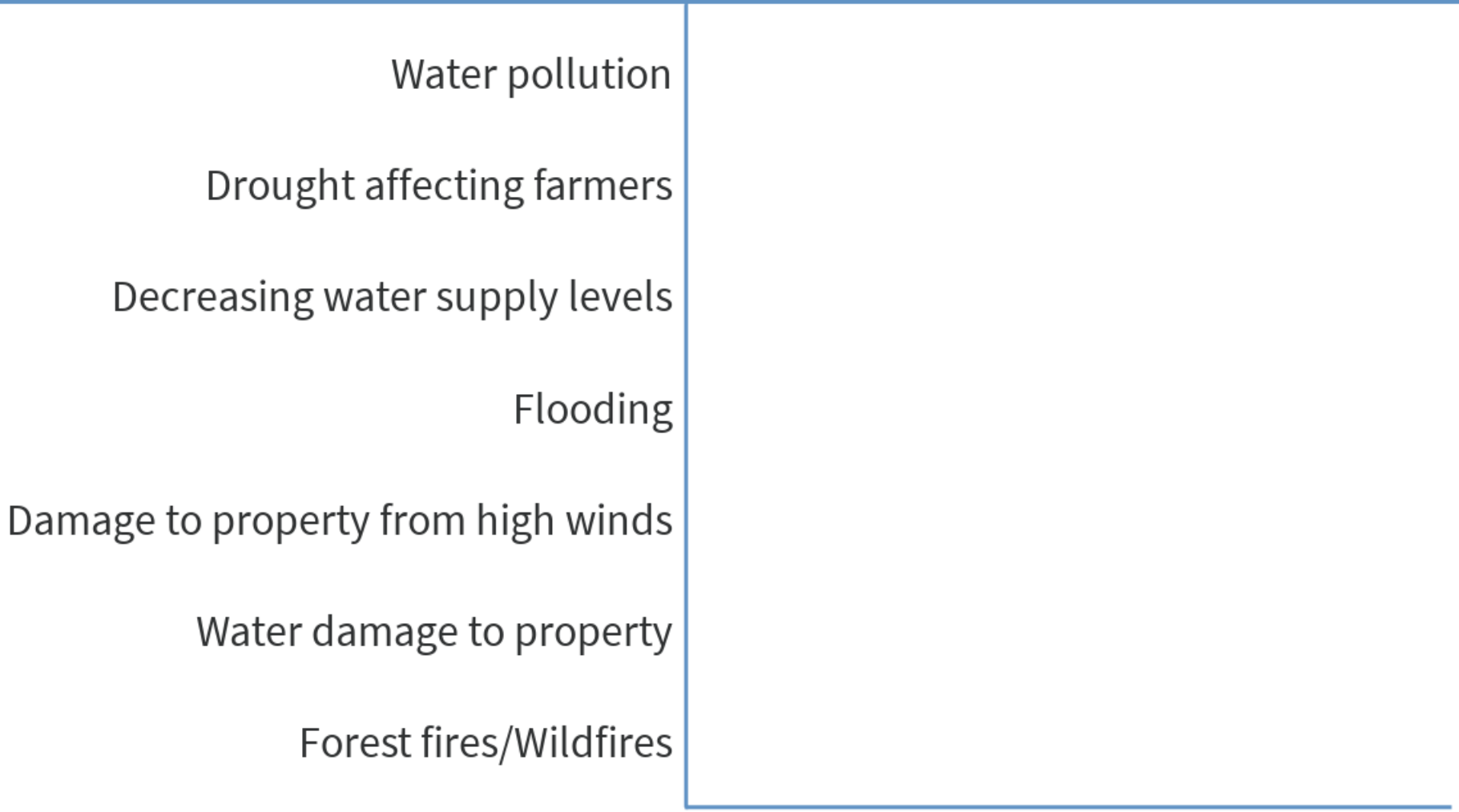
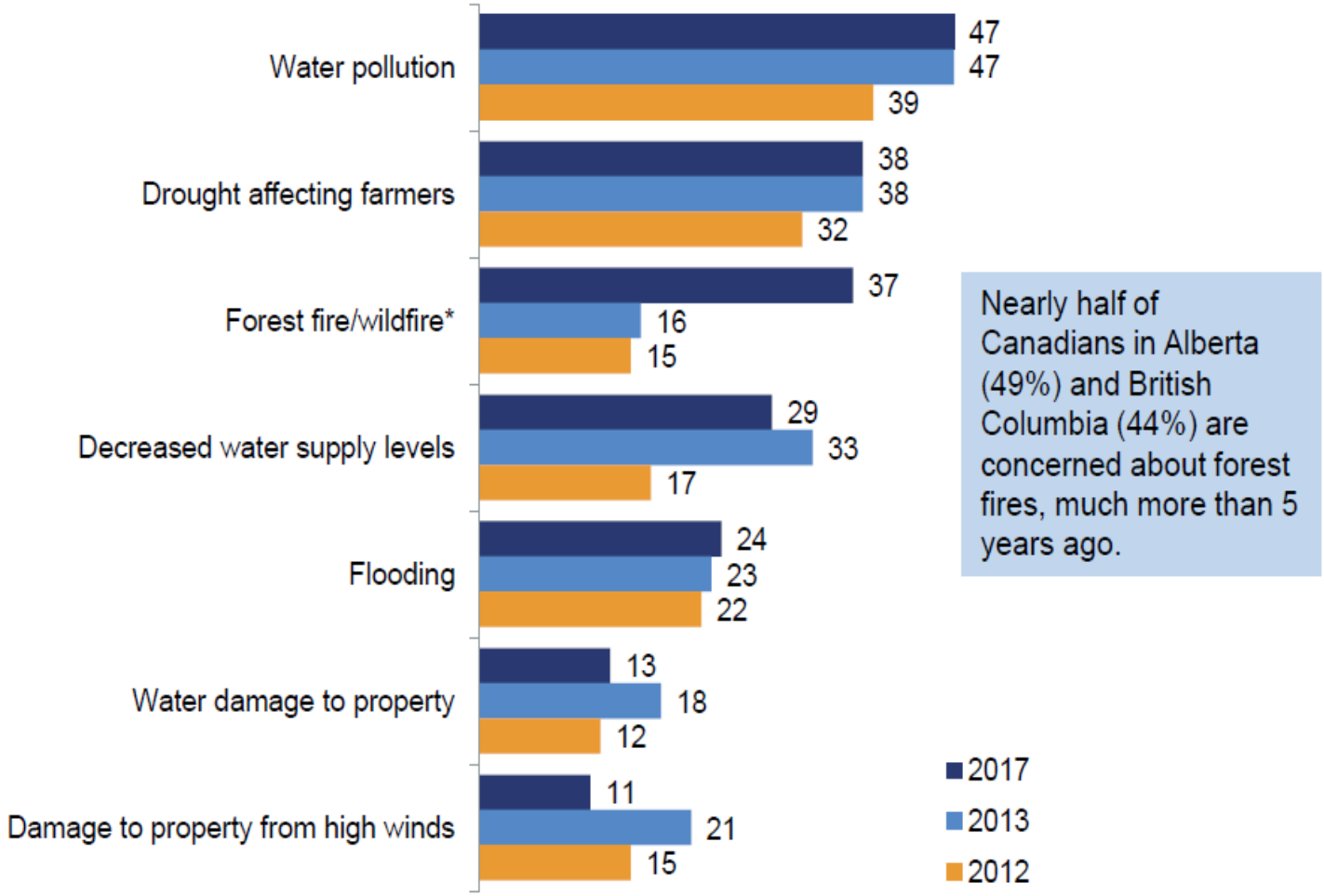
3
1
2009 2010 2011 2012 2013 2016 2017
Fresh water
Oil & gas*
Forests
Agricultural land
Fisheries
Base metals
Coal

When you think of the increasing frequency and severity of extreme weather events, which of the following is of the most concern to you?



Greatest Concern about Extreme Weather Events, Total Mentions, 2012–2017



Base: All respondents 2017 *n*=2,017, 2013 *n*=2,282, 2012 *n*=2,428

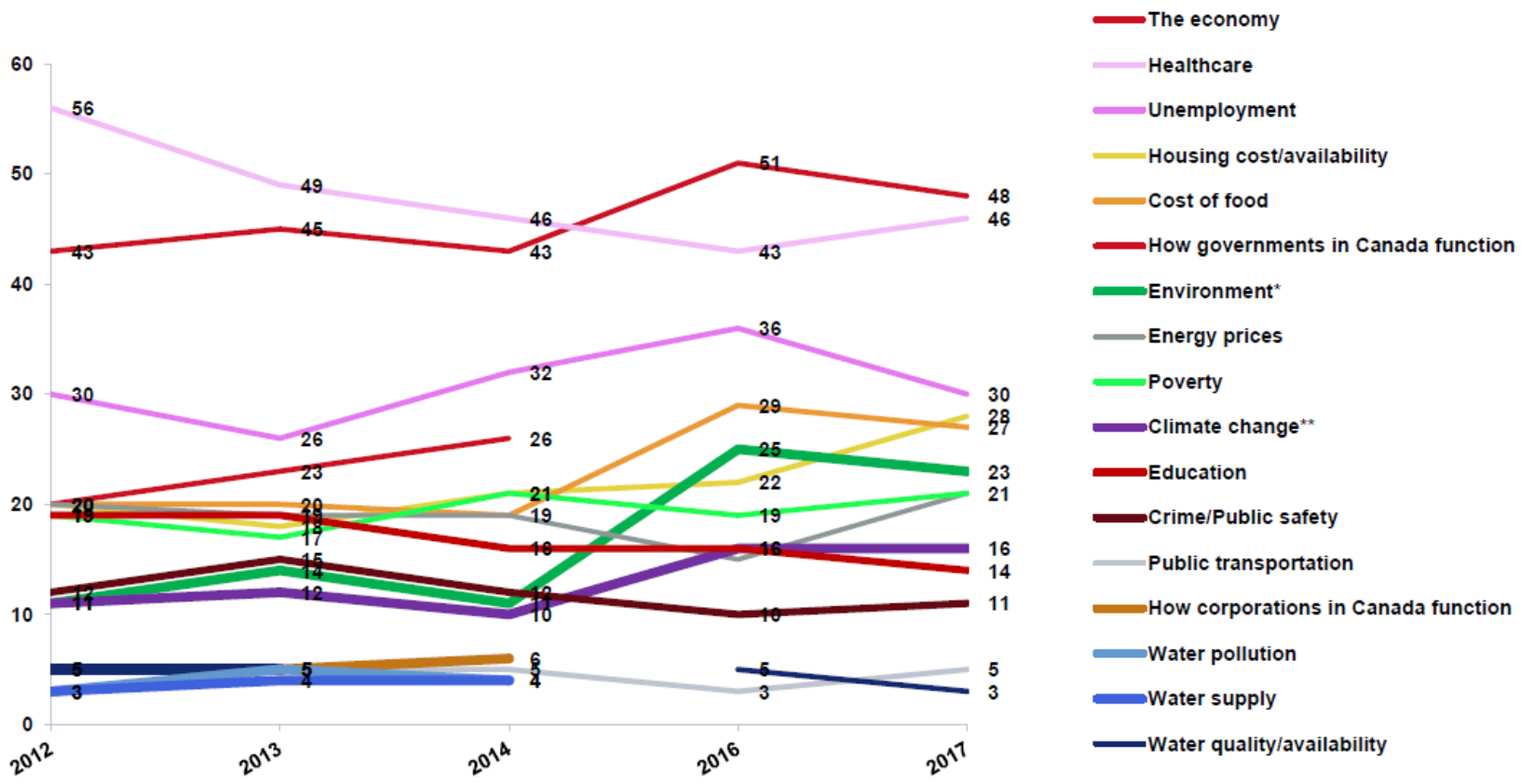
*"Wildfire" in 2013

Q. When you think of the increasing frequency and severity of extreme weather events, which two of the following most concern you?

What are some of the most important public policy issues facing Canada?

Water issues have remained low in importance for Canadians since 2012 when compared to other issues

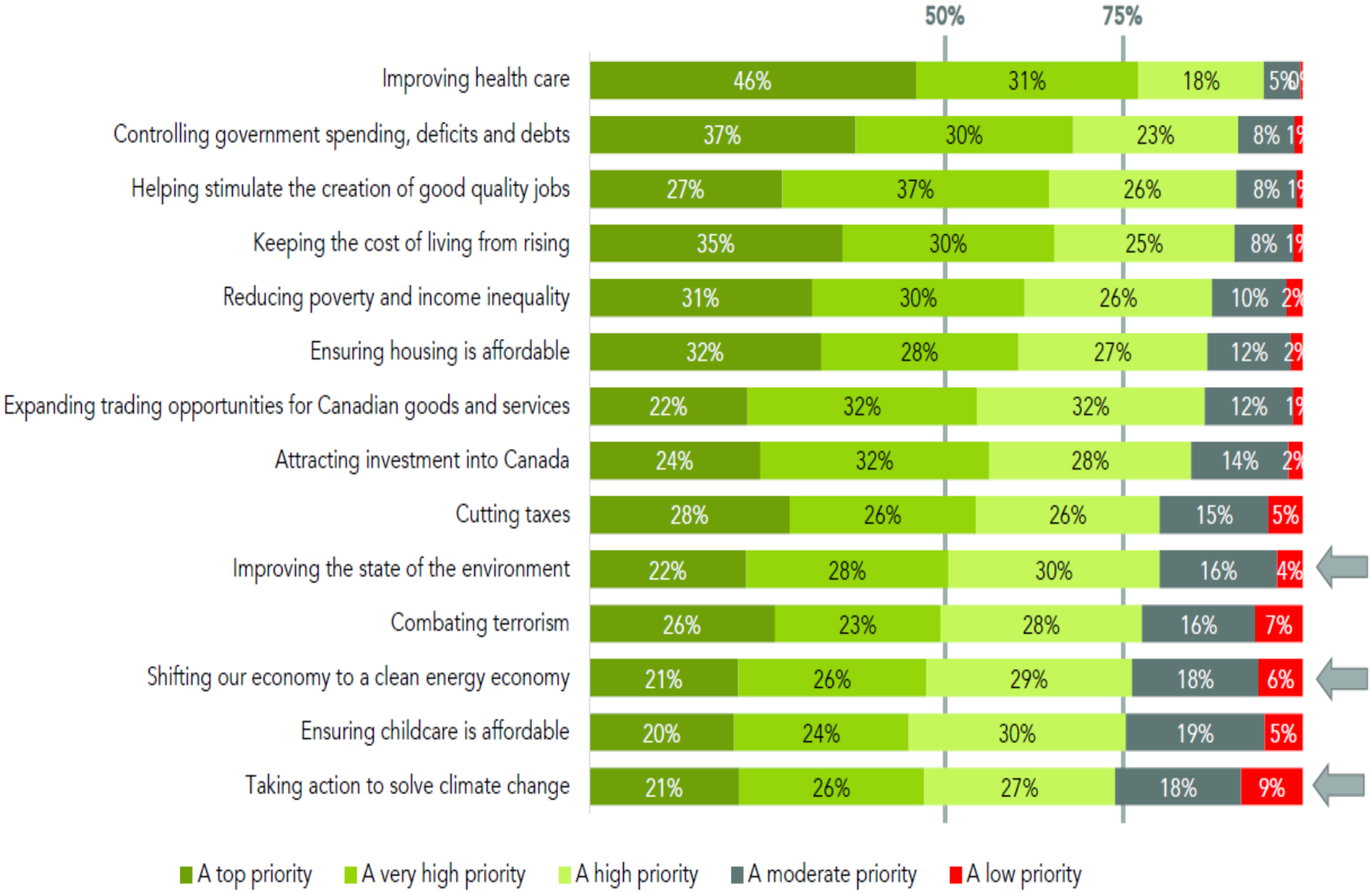
Three Most Important Issues Facing Canada, Total Mentions, 2012–2017



Base: All respondents 2017 *n*=2,017; 2016 *n*=2,194, 2014 *n*=2,074, 2013 *n*=2,282, 2012 *n*=2,428
*Overall quality of the environment in 2012, 2013 and 2014
**The impact of climate change in 2012, 2013 and 2014
Q. What do you think are the three most important issues facing Canada?

2017 RBC Canadian Water Attitudes Study

PUBLIC POLICY PRIORITIES



ABACUS DATA

Below is a list of possible public policy priorities. How much of a priority do you feel each one should be?