Chapter 22
Shifting Perspectives in an Era of Complexity and Change: Incorporating Resilience into the Water Governance of Canadian Drainage Basins

Ryan Plummer, Julia Baird, Katrina Krievins, Jennifer Fresque-Baxter, Jack Imhof, and Simon J. Mitchell

Abstract Governance has emerged as a central issue in addressing contemporary and future water challenges. Many shortcomings of past approaches to water policy in Canada are revealed in this volume as they relate to conservation (Changing Currents: A Case Study in the Evolution of Water Law in Western Canada and Patchy resources for the governance of Canada's resource patches: How hydraulic fracturing is illuminating the need to improve water governance in Canada) and

R. Plummer (✉)
Environmental Sustainability Research Centre (ESRC), Brock University,
1812 Sir Isaac Brock Way, L2S 3A1 St. Catharines, ON, Canada
e-mail: rplummer@brocku.ca

J. Baird
Research Associate, Environmental Sustainability Research Centre (ESRC), Brock University, 1812 Sir Isaac Brock Way, L2S 3A1 St. Catharines, ON, Canada
e-mail: jbaird@brocku.ca

K. Krievins
Masters Student, Sustainability Science and Society Program, Brock University,
1812 Sir Isaac Brock Way, L2S 3A1 St. Catharines, ON, Canada
e-mail: katrina.krievins@brocku.ca

J. Fresque-Baxter
Department of Environment & Natural Resources, Government of the Northwest Territories,
X1A 2 L9 Yellowknife, NT, Canada
e-mail: jennifer_fresque-baxter@gov.nt.ca

J. Imhof
Director of Conservation Ecology, Trout Unlimited Canada, 6712 Fisher St SE,
T2H 2A7 Calgary, AB, Canada
e-mail: jimhof@tucanada.org

S.J. Mitchell
St John River Advisor, WWF, Waterlution and the Canadian Rivers Institute,
St. John River, NB, Canada
e-mail: smitchell@WWFCanada.org

health (Public Health at the Watershed Scale). A fundamental shift in the prevailing mindset of government control of the hydrological cycle for human use is necessary. Resilience offers a radical departure from dominant approaches of the past and conceptual developments inform the future of water governance in an era of complexity and change. Incorporating resilience thinking into the governance of drainage basins is critical in this context. Four cases from Canada are presented to illustrate how resilience is emerging in policy and practice. Taken together, resilience thinking and resilience practice, provide a fertile ground for re-envisioning water resources and their governance.

22.1   Introduction

Canada, home to the Great Lakes and an abundance of waterways, is perceived to be a water-rich nation; however, the reality is that the majority of this water is not renewable and much of the renewable supply flows to regions where populations are sparse, creating a myth of abundance (Sprague 2007). Drought, aging infrastructure and increased consumption have led to renewable water supply shortages in many municipalities (Bakker and Cook 2011; de Loë and Plummer 2010). Water quality concerns have also been evident, including tragic incidents of drinking water contamination as well as boil water advisories that exceeded 1000 at the time of writing (www.watertoday.ca). Issues pertaining to safe drinking water are pronounced in First Nations reservations, where 93 communities (excluding British Columbia) face drinking water advisories (Health Canada 2015). Climate change is altering past assumptions about water management (see Milly et al. 2008) and is anticipated to substantially impact water related issues across the globe (Bates et al. 2008) including in Canada (Lemmen and Warren 2004). Together, these myriad water stresses will manifest in drainage basins, often referred to as watersheds in Canada, and create long term challenges for sustainability (National Round Table on the Economy and Environment 2010).

Internationally, water issues are being recognized as a crisis of governance (Global Water Partnership Technical Advisory Committee 2000; Cooley et al. 2013; OECD 2011). Water governance, in the frequently cited definition by the Global Water Partnership refers to:

> the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society (Rogers and Hall 2003, p 7).

Policy makers, practitioners and scholars alike argue that governance is similarly at the heart of Canada's water quality and quantity concerns (de Loë and Kreutzwizer 2007; Bakker and Cook 2011).

The water governance landscape in Canada is complicated, evolving, and laden with issues. Responsibility for water governance was, and to a considerable extent still is, the purview of governments in Canada. As Brandes et al. (2005, ii) observe, Canada's "…myriad public agencies share authority in 'a bewilderingly complex

administrative galaxy' that fails to address the underlying problems" and "…is in need of sober reform". Perhaps not surprising, given such observations, is the shift away from governments acting alone in a top-down manner and using command and control approaches or tools (Simms and de Loë 2010). Precipitating this movement in Canada is recognition that: government-centric approaches and tools cannot adequately address water-related problems (Simms and de Loë 2010); the complexity of water management is increasing given its essential nature in many ecosystem functions (de Loë and Kreutzwiser 2007); and, an increased emphasis on integrated management and drainage basin management (Bakker and Cook 2011).

While governments and regulations remain an essential part of water governance, a rich dialogue has opened about the appropriateness of other models in Canada. For example, the *Water Act* modernization process in British Columbia gave impetus to envision transformative watershed governance (see Brandes et al. 2014). Simms and de Loë (2010) identified several water governance challenges in Canada as described by practitioners, including leadership and commitment; legitimacy; actors, roles and relationships; knowledge; integrating institutions; resources and capacity; accountability; learning; adaptation; and, evaluation.

Adding to the discussion of appropriate water governance models is the acknowledgement that we are in an era of complexity, uncertainty and change, prompting reconsideration of the assumptions about water and society. Folke (2003, p 2033), accordingly, argued for a transition to thinking for resilience and stressed that it requires:

> …a shift from trying to control and allocate freshwater flows in an optimal manner for various human uses to recognition of the necessity to actively manage the essential role of freshwater in dynamic landscapes faced with uncertainty and surprise.

Over a decade later, Schoeman et al. (2014, p 378) documented emergence of such a water paradigm.

This chapter unpacks the concept of resilience and explores the body of scholarship in relation to water governance. While conceptually rich, there is much less experience with resilience practice. Evidence that resilience is informing water governance of drainage basins in Canada is explored through four cases. In line with the work of Clancy (2014), drainage basins focus the exploration because they represent interconnected systems of nature and humans that have long been considered when making decisions about freshwater and its management in Canada. Insights from scholarship, as well as these emerging experiences, provide a growing basis from which to consider resilience in Canadian water governance.

22.2   Resilience Thinking, Water Systems, and Their Governance

Resilience is a concept that has evolved over time (see Folke 2006; Plummer 2010; Krievins et al. 2014). With acknowledgement of its multiple meanings, the term here is used in the sense of social-ecological resilience. Social-ecological resilience is underpinned by two complimentary perspectives: complex adaptive systems,

which takes an evolving view of nature characterized by uncertainty, self-organization and non-linearity (Holling and Gunderson 2002; Holling et al. 2002) and social-ecological systems where ecological and social systems are inextricably linked and delineations between them are considered artificial (Berkes and Folke 1998; Berkes et al. 2003).

Social-ecological resilience emphasizes the ability to navigate complexity, uncertainty and change. It is understood as:

> (1) the amount of disturbance a system can absorb and still remain within the same state or domain of attraction, (2) the degree to which the system is capable of self-organization (versus lack of organization, or organization forced by external factors), and (3) the degree to which the system can build and increase the capacity for learning and adaptation (Folke 2006, p 259–260).

Resilience thinking (Walker and Salt 2006; Folke et al. 2010) provides a theoretical framework for understanding social-ecological systems and integrating the core elements of resilience, adaptability and transformability. Folke et al. (2010) explain in this framework:

> Resilience is the tendency of a SES [social-ecological system] subject to change to remain within a stability domain, continually changing and adapting yet remaining within critical thresholds. Adaptability is a part of resilience. Adaptability is the capacity of a SES to adjust its responses to changing external drivers and internal processes and thereby allow for development within the current stability domain, along the current trajectory. Transformability is the capacity to create new stability domains for development, a new stability landscape, and cross thresholds into a new development trajectory.

Insights into building resilience are developing as resilience research accumulates. Reflecting upon experiences conveyed in their seminal work on navigating social-ecological systems, Folke et al. (2003, p 354–355) identified four critical factors for building resilience and adaptive capacity:

> …learning to live with change and uncertainty; nurturing diversity for reorganization and renewal; combining different types of knowledge for learning; and creating opportunity for self-organization toward social-ecological sustainability.

More recently, efforts have been made to identify universal principles that indicate resilience or may enhance it. Biggs et al. (2012) identified seven principles for enhancing resilience of ecosystem services. Three of the principles (diversity and redundancy, connectivity, and slow variables and feedbacks) relate to system properties to be managed, and the remaining four principles (understanding social-ecological systems as complex adaptive systems, learning and experimentation, participation, and polycentricity) are considered key attributes of the governance system. Frequent co-occurrence and high interdependencies of these principles are observed which requires future research to enhance understanding and make them operationally applicable.

Freshwater in relation to resilience was identified as an unexplored area by Folke in 2003, but attention to it has increased since that time (e.g., Folke 2003; Galaz 2007; Milman and Short 2008; Rockström et al. 2014; Plummer et al. 2014, 2016a). While research focusing specifically on resilience and water governance is more limited, a few salient works have explored the connection. Folke's (2003) founda-

tional effort outlines the resilience perspective and contrasts difference in world-views by comparing examples of modern aquaculture with two examples of adaptive co-management in Sweden, an approach to catchment-based stewardship. In so doing, he offered insights into social dimensions of managing freshwater, social features of resilience, and multi-level catchment governance. Galaz (2007, p 7) examined integrated water resources management (IWRM) as a strategic approach in the international policy arena and understanding of freshwater resources in terms of resilience and their governance. His findings revealed:

> …a substantial lag between advances in research on what constitutes resilient intercon-nected freshwater resources and their governance, and what is being promoted by policy makers at several policy scales, from the international to the national arena.

Most recently, Plummer et al. (2014) conducted a Delphi study of global experts in aquatic systems governance and resilience to reconcile diverse terminology and develop consensus on essential key attributes. These attributes related to specified resilience (i.e., resilience to specific disturbances) and general resilience (i.e., gen-eral capacity to respond to disturbances of all kinds including surprises) (Table 22.1). While the study by Plummer et al. (2014, p 15) consolidated these attributes, it recognized that:

> ensuring the core aspects of resilience are held, while infusing the spirit of the concept into the important dialogue on governance and aquatic systems, is a challenge for researchers, decision-makers, and citizens moving forward.

Practitioners and policy makers will immediately be confronted by the need to tradeoff specified and general attributes (Plummer et al. 2014). Moreover, the strengths of resilience attributes will need to be considered in light of their costs. For example, polycentric governance can also display disadvantages such as diffi-culties in making collective decisions, increased transaction costs, and loss of dem-ocratic accountability (Huitema et al. 2009).

Finally, it is important to acknowledge the critical discourse emerging about resilience. Criticism of resilience thinking has largely come from scholars in the

Table 22.1 Resilience attributes essential for governance

Specified resilience attributes	General resilience attributes
Adaptive planning	Institutional flexibility
Polycentric network structure and the presence of boundary organizations	Decentralized system
Diverse actor participation	Inclusive participation and building a shared understanding
Authority/leadership for efficient, adaptive responses	Strong, not individually concentrated, leadership
Equity and transparency	Wide range of ecosystem services included in planning
Capacity to self-organize	
Social memory to maintain knowledge base	
Precautionary risk assessment and reduction strategies	

Adapted from Plummer et al. (2014)

social sciences (e.g., Davidson 2010; Cote and Nightingale 2012; Hornborg 2013; Brown 2014; Olsson et al. 2015). As Brown (2014, p 107) summarizes:

> the application of resilience concepts to social and ecological systems and dilemmas has been roundly critiqued for undertheorizing social dimensions, and human geographers in particular have been an important critical voice in highlighting the omission of social, political and cultural dynamics from different resilience literatures.

22.3 Signs of Resilience Thinking in Canadian Drainage Basin Governance

While the concept of resilience has grown in importance and gained widespread uptake in terms of research and policy, a gap is evident with the "…demonstrated capacity to govern for resilience in practice…" (Wilkinson 2012, p 319).

Difficulties in applying the idea of resilience have been noted. For example, the need for definitions and metrics to facilitate making resilience operational is necessary (Kerner and Thomas 2014). Fragmentation by the variety of disciplines and strands within resilience research itself has led to limited coherence of important factors, in particular context, to build resilience and the ways they may be made operational (Biggs et al. 2015). Walker and Salt (2012) argue, in light of such challenges, that applying resilience thinking in practice is a logical next step.

To the best of our knowledge, the manner in which resilience thinking is informing water governance practice in Canada is not well understood. However, we contend that evidence is emerging throughout Canada that resilience ideas are shaping conversations about water governance as well as being put into practice. The following examples highlight signs of resilience thinking in Canadian drainage basin governance and illustrate how resilience concepts may be put into practice.

22.3.1 St. John River Basin

The St. John River Basin is an international transboundary basin (situated in the state of Maine in the USA, and the provinces of New Brunswick and Quebec in Canada) that is over 55,000 km^2 in area and has a main stem of 678 km that flows from the north Maine woods to the Bay of Fundy at Saint John, New Brunswick. It is home to over half a million people, has a diversity of flora and fauna and a number of rare, threatened and endangered species. It has some of the oldest settlements in Canada and a strong and rich natural and cultural history that dates back some 8500 years to the arrival of the Wolastoquiyik, known today as the Maliseet. The home river of the Maliseet is the St. John, or Wolastoq, "the good and bountiful river".

World Wildlife Fund (WWF) (Canada) has been working in the region for 3 years, with much of their effort centered on the health of the river and surrounding communities, habitats and species. WWF's recently released Watershed Reports (www.watershedreports.wwf.ca) is a key tool for building a common understanding of freshwater health and threats nationally, regionally and locally. On the St. John River, this tool has helped to refine the understanding of river health; and, when combined with the Social Ecological Inventory (SEI) and social network analysis through a joint research project with Brock University, a greater understanding of who is doing what and where in support of a healthy river has emerged (see Plummer et al. 2016b). With over 160 actors identified in the study as contributing to river health, the next obvious question is what is the nature of the relationship among these actors?

Understanding who is funding these efforts, who is contributing to regulation and policy, who is responsible for enforcement, who is acting on the ground to ensure healthy waters, and how they are connected, builds new knowledge about the watershed and presents opportunities to bridge important gaps between actors within and among sectors and across this transboundary basin. In so doing, a number of the specified and general resilience attributes for governance (e.g., equity and transparency, diverse actor participation, etc.) are flourishing. Moreover, application of the SEI demonstrates a technique for identifying key actors and engaging them at the drainage basin scale. In drawing social and ecological connections among scales (e.g., specific sites, sub-basins) it informs decision-making in the system and contributes to resilience.

As WWF's efforts on the St. John River / Wolastoq mature, resilience is gaining prominence. Key aspects of resilience thinking, including diverse actor participation and interconnectedness (in terms of interests and scales), inclusion and consideration of different knowledges, and a focus on learning and adaptation are being integrated into municipal climate vulnerability assessments and the development of adaptation plans. Healthy waters are understood to be complex systems in which social, economic, ecological, traditional and spiritual dimensions are constantly interacting and influencing one another. While resilience thinking is not a panacea and does not offer a prescription of how to make hard choices/trade-offs between investments in specified and general resilience, it helps to understand how interacting systems of people and nature operate within the river basin, assists in navigating different values and interests, and avails management approaches with capacity to deal with complexity, uncertainty and unexpected changes. Ultimately, resilience thinking provides a conceptual framework for devising new ways to mitigate impacts and seize opportunities resulting from rapid change, and can catalyze the transition towards a future where humans and nature thrive, and are better prepared to engage in continuous learning and adaptation, in support of healthy freshwaters.

22.3.2 Water Stewardship in Canada's Northwest Territories

In Canada's Northwest Territories (NWT), water is viewed as a fundamental human right, which was recognized in March 2007 by the 15th Assembly of the Northwest Territories in a unanimous motion (Government of the Northwest Territories (GNWT) and Aboriginal Affairs and Northern Development Canada (AANDC) 2010). Water is critical for social, cultural, economic and spiritual purposes, and supports Northern livelihoods (including subsistence and commercial harvesting, travel, and recreation).

Protecting aquatic ecosystems – and the people, plants, birds, fish, wildlife and processes that rely on these – is paramount for NWT water governance. Northerners have expressed concerns about impacts to water from a wide range of drivers, including climate change, industrial development and activities in upstream jurisdictions. These concerns pointed to a need for a coordinated and collaborative approach to NWT water stewardship.

Released in 2010, *Northern Voices, Northern Waters: The NWT Water Stewardship Strategy*[1] (the 'Strategy'), was a collaborative endeavour between Aboriginal, municipal, territorial and federal governments, regulatory boards, environmental organizations, industry, academic partners and the public (GNWT and AANDC 2010). The vision of the Strategy, as the guiding policy document for water management in the NWT, is that "the waters of the Northwest Territories will remain clean, abundant and productive for all time" (GNWT and AANDC 2010).

The development of the Strategy shifted water-related work from a focus on government responsibilities and agency-specific mandates towards a broader collective mandate jointly shared by NWT Water Partners. Through its more coordinated approach, the Strategy has created collaborative opportunities for water stewardship, meaning partners can better address their broader interests, needs, priorities and responsibilities through working together. As partners learn and work together, improvements to collaboration and coordination continue to progress.

In 2011, an associated Action Plan identified key priorities, deliverables, timelines and lead agencies for stewardship activities to ensure accountability and progress towards the Strategy's vision and goals (GNWT and AANDC 2011). Water partners are currently implementing activities that support priorities under the Strategy, including (but not limited to): negotiation of bilateral water management agreements with neighbouring Mackenzie River Basin jurisdictions; community-based aquatic ecosystem health research and monitoring; source water protection planning; education and outreach; youth engagement; capacity-building and training; water regulatory initiatives; traditional knowledge activities; on-the-land programs; and, information management (GNWT and AANDC 2011).

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[1] For more information on the Strategy, partners involved, and past and current activities, please visit: nwtwaterstewardship.ca.

The Strategy promotes resilience of NWT waters through a number of attributes, including[2]:

Collaboration and Integration Core to the success of Strategy development and implementation has been collaboration of multiple, diverse partners in tackling complex issues. The Strategy recognizes stewardship as a collective responsibility, and promotes people with different mandates, experiences and knowledge working together to make sound decisions for protection of aquatic ecosystems.

Ecosystem-Based Approach The Strategy adopts a holistic approach, which considers the multiple nested scales at which stewardship, management and decision-making are enacted (from the local to Basin-wide), and the interconnectedness between all parts of the ecosystem, including people as part of that system.

Adaptability Information gathered through research and monitoring supports better understanding of aquatic ecosystems to make appropriate decisions. The Strategy allows sufficient flexibility to adapt management to social and ecological changes, and to adjust practices as new information is gathered.

Multiple Knowledge Systems The Strategy is built on the importance of using multiple knowledge systems to make decisions. Drawing on the strengths of traditional and local knowledge and western science together can provide a more holistic understanding of the environment, change, and strategies to address change.

The attributes above align with recognized attributes of resilience for aquatic system governance (Plummer et al. 2014). In 2015, implementation of the Strategy underwent an independent evaluation, and a new Action Plan is being collaboratively developed to set priorities for 2016–2020. The new Action Plan will continue to reflect the above attributes in efforts to promote resilient ecosystems, people, communities and livelihoods.

22.3.3   *The Cowichan Watershed*

Resilience concepts are inherently compatible with watershed governance: notions of inclusive participation, building a shared understanding, ensuring social memory (redundancy), capacity for self-organization, and considering ecosystem services in planning (Biggs et al. 2012; Plummer et al. 2014) all resonate with multi-stakeholder governance at the watershed scale. But, these attributes may not be considered in resilience terms by those engaged in governance. Researchers from Brock University and the University of Victoria facilitated a resilience workshop research study to assess the potential for learning about resilience to enhance resilience at a watershed

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[2] Note: This is a not an exhaustive list of attributes in the Strategy that promote resilience, but are rather selected examples.

scale. One of the watersheds of focus was the Cowichan Watershed on Vancouver Island in British Columbia.

The Cowichan Water Board (CWB), established in 2010, has been active in leading water management efforts in the Cowichan Watershed. They experience a range of issues related to both water quantity and quality, including management of a weir and associated water supply and demand issues and water pollution from several sources including agriculture, industry and sewage (Hunter et al. 2014). Several members of the CWB and other interested individuals from the community took part in a 2-day workshop that introduced resilience concepts and illustrated how these concepts could be applied in practice. The workshop offered opportunities to build resilience among participants in terms of watershed governance by working through exercises:

1. Building a shared understanding of what was valued about the watershed;
2. Building a shared understanding of what threatens the watershed (considering scales above and below the focal scale of the watershed);
3. Identifying opportunities to build specified resilience (i.e., resilience to specific, known disturbances) and working through an example; and,
4. Identifying attributes of general resilience (i.e., resilience to unknown, unexpected disturbances or attributes that confer resilience to multiple specific disturbances) held by the CWB and attributes that could be strengthened.

The workshop provided an introduction to a much larger discussion and process of incorporating resilience thinking into their governance practice. It offered an opportunity to approach governance from a different perspective – considering scales, known and unknown disturbances, and adaptive capacity – and engage in decision-making based on this perspective. To assess the impacts of the workshop immediately and over time, a questionnaire was administered. The focus of the questionnaire was on learning, as learning is a key aspect of resilience and encouraging learning is considered to enhance resilience (Biggs et al. 2012). A framework that measured three learning types (Baird et al. 2014) was used: cognitive (learning new facts or restructuring knowledge); normative (changing viewpoints, norms, and/or values); and, relational (improved understanding of others' mindsets, developing relationships, developing trust). Some evidence of all three types of learning was measured immediately after the workshop, and persisted 6 months after the workshop was held (Baird et al. 2016). Some participants indicated that efforts have been made to incorporate resilience practice into governance of the watershed, and two thirds of respondents stated that they increased the network of those they communicate with and sharing information about resilience.

Does learning about resilience enhance resilience in watershed governance? The results of the study provide positive indications that it does. While learning is critical for resilience, it is insufficient on its own to ensure a resilient system. However, the discussions during the workshop indicate that other aspects of resilience, including building

a shared understanding and including ecosystem services in planning, may have been enhanced as well and this bodes well for the CWB and the Cowichan Watershed.

22.3.4 Stream Rehabilitation, From Form to Function: Trout Unlimited Canada Training Program

Examples of degraded streams and stream corridors are prevalent throughout Canada as a result of historic and contemporary uses of, and alterations to, these systems and the watersheds in which they are situated (Fisheries and Oceans Canada 2006). Further degradation as a result of continued exploitation and manipulation of streams and their corridors, coupled with the effects of changing temperature and precipitation patterns associated with climate change, is likely and the consequences are uncertain (Imhof and FitzGibbon 2014).

Rehabilitation, the "reparation of ecosystem processes, productivity, and services rendered" (Clewell and Aronson 2013, p 203), can serve as a critical part of restoring and enhancing watershed resilience by rebuilding the functional characteristics of a stream within its watershed so that it is capable of dealing with higher variability while maintaining its health. Increasingly, communities and local organizations are playing an important and expanding role in achieving the goal of enhanced watershed resilience through rehabilitation (Imhof and FitzGibbon 2014). To support volunteer groups and communities in this endeavour, a consortium of conservation organizations and individuals developed the *Stream Rehabilitation, From Form to Function* training program (formerly the *Aquatic Renewal Stream Restoration Training Program*). Led by Trout Unlimited Canada (TUC), a national not-for-profit organization, the program's series of six workshops provide volunteers and young professionals with a basic level of training on the development and implementation of stream and watershed rehabilitation projects and programs. More specifically, the program helps groups and individuals understand that simply placing structures in a stream will not restore resilience. Rather, understanding the causes of dysfunction in the stream, and the watershed more broadly, and strategically applying the appropriate techniques and approaches to restore the functions of the system will aid in enhancing watershed resilience.

One of the primary reasons for the development of the training program was to foster social memory to maintain a knowledge base around stream and watershed rehabilitation. Engaging and mentoring the next generation of watershed stewards with the capacity to lead rehabilitation projects in their local watersheds is a central aim of the program. Building this community of practice sets the stage for watershed stewardship with local leadership that is efficient and well suited to responding adaptively to local issues as they arise.

The approach to rehabilitation taught in TUC's training program differs from more traditional approaches in that streams and watersheds are treated as complex, dynamic social-ecological systems for which consideration must be given to uncer-

tainty, surprise, feedbacks, and temporal and spatial scale. In taking this novel approach, the program emphasizes several resilience principles identified by Plummer et al. (2014) including adaptive planning, diverse actor participation, inclusive participation and building a shared understanding, and including a wide range of ecosystem services in planning. Rather than simply discussing these principles, the program goes one step further and illustrates how they can be put into practice in the context of stream rehabilitation.

22.4 Concluding Reflections

Effectively navigating the landscape of water governance in Canada is essential and doing so will be no easy task given the complexity, uncertainty and change that characterize water resources. Positioned within a different world view, resilience thinking provides a distinct way for understanding water systems, and correspondingly, offers alternative approaches to drainage basin governance than have been used in the past.

Resilience and water governance is an emerging area of scholarship. Unpacking the concept of resilience and its relation to water governance reveals a fertile conceptual ground. Inroads into frameworks for resilience of governance in aquatic systems, and more broadly for environmental governance, are being made by some scholars (e.g., Walker and Salt 2006; Biggs et al. 2012; Plummer et al. 2014). Continued efforts in this direction may enhance understanding across varied settings.

Incorporating resilience into the unfolding dialogue about water governance in Canada is essential. Despite this imperative "it still remains a huge challenge to bring about a convergence between resilience and adapting institutions" (Boyd and Folke 2012, p 277). One aspect of this challenge is how to incorporate resilience thinking into existing institutions and dominant modes of governance. In the United States, for example, Benson and Garmestani (2011) examined the question of integrating resilience thinking into existing governing federal agencies. Some of the several challenges they found to integration include existing laws and regulations which ignored ecological complexity, the tendency to treat social and ecological systems in an uncoupled fashion, and the absence of enforceable standards regarding resilience. A more encompassing aspect is to incorporate principles for building resilience (Biggs et al. 2012, 2015) when addressing the water governance challenges, such as those identified in Canada by Simms and de Loë (2010).

Translating resilience thinking into resilience practice is an identified gap (Wilkinson 2012) and necessary next step (Walker and Salt 2012). To some extent, this will be facilitated or constrained by the extent of encouragement and support from existing agencies as well as the degree of incorporation at various scales within the water governance landscape. The four cases in this chapter demonstrate aspects of resilience being incorporated into drainage basin governance in Canada. Collating

and communicating experiences from the field are essential. A primer on incorporating resilience into drainage basin management (Krievins et al. 2015) is intended to begin a discussion in Canada about resilience at the drainage basin scale, with those who work within it, and the broader water policy community.

References

Baird, J., Plummer, R., Haug, C., et al. (2014). Learning effects of interactive decision-making processes for climate change adaptation. *Global Environmental Change, 27*, 51–63.

Baird, J., Plummer, R., Moore, M.-L., et al. (2016). Introducing resilience practice to watershed groups: What are the learning effects? *Society & Natural Resources, 29*, 1214–1229.

Bakker, K., & Cook, C. (2011). Water governance in Canada: Innovation and fragmentation. *International Journal of Water Resources, 27*(2), 275–289.

Bates, B. C., Kundzewicz, Z. W., & Wu, S. et al. (Eds.). (2008). *Climate change and water*. Technical Paper of the Intergovernmental Panel on Climate Change (IPCC). Geneva: IPCC Secretariat.

Benson, M. H., & Garmestani, A. S. (2011). Can we manage for resilience? The integration of resilience thinking into natural resource management in the United States. *Environmental Management, 48*, 392–399.

Berkes, F., & Folke, C. (1998). Linking social and ecological systems for resilience and sustainability. In F. Berkes & C. Folke (Eds.), *Linking social and ecological systems: Management practices and social mechanisms for building resilience* (pp. 1–25). New York: Cambridge University Press.

Berkes, F., Colding, J., & Folke, C. (Eds.). (2003). *Navigating social-ecological systems: Building resilience for complexity and change*. Cambridge: Cambridge University Press.

Biggs, R., Schlüter, M., Biggs, D., et al. (2012). Toward principles for enhancing the resilience of ecosystem services. *Annual Review of Environment and Resources, 37*, 421–448.

Biggs, R., Schlüter, M., Schoon, M. L., et al. (2015). *Principles for building resilience: Sustaining ecosystem services in social-ecological systems*. New York: Cambridge University Press.

Boyd, E., & Folke, C. (2012). Conclusions: Adapting institutions and resilience. In E. Boyd & C. Folke (Eds.), *Adapting institutions: Governance, complexity and social-ecological resilience* (pp. 264–280). Cambridge: Cambridge University Press.

Brandes, O. M., Ferguson, K., M'Gonigle, M., et al. (2005). *At a watershed: Ecological governance and sustainable water management in Canada*. Victoria: POLIS Project on Ecological Governance.

Brandes, O. M., O'Riordan, J., O'Riordan, T., et al. (2014). *A blueprint for watershed governance in British Columbia*. Victoria: POLIS Project on Ecological Governance.

Brown, K. (2014). Global environmental change: A social turn for resilience? *Progress in Human Geography, 38*(1), 107–117.

Clancy, P. (2014). *Freshwater politics in Canada*. North York: University of Toronto Press.

Clewell, A. F., & Aronson, J. (2013). *Ecological restoration: Principles, values, and structure of an emerging profession* (2nd ed.). Washington, DC: Island Press.

Cooley, H., Ajami, N., Ha, M. L., et al. (2013). *Global water governance in the 21st century*. Oakland: Pacific Institute.

Cote, M., & Nightingale, A. J. (2012). Resilience thinking meets social theory: Situating social change in socio-ecological systems (SES) research. *Progress in Human Geography, 36*(4), 475–489.

Davidson, D. J. (2010). The application of the concept of resilience to social systems: Some sources of optimism and nagging doubts. *Society & Natural Resources, 23*, 1135–1149.

de Loë, R., & Kreutzwizer, R. (2007). Challenging the status quo: The evolution of water gover-
    nance in Canada. In K. Bakker (Ed.), *Eau Canada: The future of Canada's water* (pp. 85–104).
    Vancouver: UBC Press.
de Loë, R., & Plummer, R. (2010). Climate change, adaptive capacity, and governance for drinking
    water in Canada. In D. Armitage & R. Plummer (Eds.), *Adaptive capacity and environmental
    governance* (pp. 157–178). Heidelberg: Springer.
Fisheries and Oceans Canada. (2006). *Ecological restoration of degraded aquatic habitats: A
    watershed approach*. Available via Fisheries and Oceans Canada. http://www.dfo-mpo.gc.ca/
    library/321286.pdf. Accessed 18 Sept 2015.
Folke, C. (2003). Freshwater for resilience: A shift in thinking. *Philosophical Transactions of the
    Royal Society of London B Biological Sciences, 358*(1440), 2027–2036.
Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analy-
    ses. *Global Environmental Change, 16*(3), 253–267.
Folke, C., Colding, J., & Berkes, F. (2003). Synthesis: Building resilience and adaptive capacity in
    social-ecological systems. In F. Berkes, J. Colding, & C. Folke (Eds.), *Navigating social-
    ecological systems: Building resilience for complexity and change* (pp. 352–387). New York:
    Cambridge University Press.
Folke, C., Carpenter, S. R., Walker, B., et al. (2010). Resilience thinking: Integrating resilience,
    adaptability and transformability. *Ecology and Society, 15*(4), 20.
Galaz, V. (2007). Water governance, resilience and global environmental change – A reassessment
    of integrated water resources management (IWRM). *Water Science and Technology, 56*(4),
    1–9.
Global Water Partnership Technical Advisory Committee. (2000). *Integrated water resources
    management* (TAC background papers, 4). Stockholm: Global Water Partnership.
Government of the Northwest Territories and Aboriginal Affairs and Northern Development
    Canada. (2010). *Northern voices, northern waters: NWT Water Stewardship Strategy*.
    Yellowknife: Government of the Northwest Territories.
Government of the Northwest Territories and Aboriginal Affairs and Northern Development
    Canada. (2011). *NWT water stewardship: A plan for action, 2011–2015*. Yellowknife:
    Government of the Northwest Territories.
Health Canada. (2015). *Drinking water and wastewater*. Available via Health Canada. http://www.
    hc-sc.gc.ca/fniah-spnia/promotion/public-publique/water-eau-eng.php. Accessed 18 Sept
    2015.
Holling, C. S., & Gunderson, L. H. (2002). Resilience and adaptive cycles. In L. H. Gunderson &
    C. S. Holling (Eds.), *Panarchy: Understanding transformations in human and natural systems*
    (pp. 25–62). Washington, DC: Island Press.
Holling, C. S., Gunderson, L. H., & Ludwig, D. (2002). In quest of a theory of adaptive change. In
    L. H. Gunderson & C. S. Holling (Eds.), *Panarchy: Understanding transformations in human
    and natural systems* (pp. 3–22). Washington, DC: Island Press.
Hornborg, A. (2013). Revelations of resilience: From the ideological disarmament of disaster to
    the revolutionary implications of (p)anarchy. *Resilience, 1*(2), 116–129.
Huitema, D., Mostert, E., Egas, W., et al. (2009). Adaptive water governance: Assessing the insti-
    tutional prescriptions of adaptive (co)management form a governance perspective and defining
    a research agenda. *Ecology and Society, 14*(1), 26.
Hunter, R., Brandes, O., & Moore, M. -L. et al. (2014). *The Cowichan watershed board: An evolu-
    tion of collaborative watershed governance*. Available via POLIS Project on Ecological
    Governance. http://poliswaterproject.org/publication/761. Accessed 18 Sept 2015.
Imhof, J. G., FitzGibbon, J. E. (2014, June 24–26). *Restoring streams and their watersheds by
    building the capacity of local communities: A watershed and stream rehabilitation training
    program*. Presentation at the Adaptation in the Great Lakes Region conference, Ann Arbor,
    Michigan.
Kerner, D. A., & Thomas, J. S. (2014). Resilience attributes of social-ecological systems: Framing
    metrics for management. *Resources, 3*, 672–702.

Krievins, K., Plummer, R., & Baird, J. (2014). *Resilience: An annotated bibliography*. Available via Environmental Sustainability Research Centre, https://dr.library.brocku.ca/handle/10464/5239. Accessed 18 Sept 2015.

Krievins, K., Baird, J., Plummer, R., et al. (2015). *Resilience in a watershed governance context: A primer*. St. Catharines: Environmental Sustainability Research Centre.

Lemmen, D. S., & Warren, F. J. (2004). *Climate change impacts and adaptation: A Canadian perspective*. Ottawa: Natural Resources Canada.

Milly, P. C. D., Betancourt, J., Falkenmark, M., et al. (2008). Stationarity is dead: Whither water management. *Science, 319*, 73–574.

Milman, A., & Short, A. (2008). Incorporating resilience into sustainability indicators: An example for the urban water sector. *Global Environmental Change, 18*(4), 758–767.

National Round Table on the Economy and Environment. (2010). *Changing currents: Water sustainability and the future of Canada's natural resource sectors*. Ottawa: NRTEE.

OECD. (2011). *Water governance in OECD countries: A multi-level approach*. Paris: OECD Publishing. doi:10.1787/9789264119284-en

Olsson, L., Jerneck, A., Thoren, H., et al. (2015). Why resilience is unappealing to social science: Theoretical and empirical investigations of the scientific use of resilience. *Science Advances, 1*(4), e1400217.

Plummer, R. (2010). Social-ecological resilience and environmental education: Synopsis, application, implications. *Environmental Education Research, 16*(5–6), 493–509.

Plummer, R., Baird, J., Moore, M.-L., et al. (2014). Governance of aquatic systems: What characterizes resilience? *International Journal of Water Governance, 2*(4), 1–18. doi:10.7564/14-IJWG51.

Plummer, R., Baird, J., Bullock, R., et al. (2016a). *Probing the relationship between ecosystem perceptions and approaches to environmental governance: An exploratory content analysis of seven water dilemmas*. Resilience: International Policies, Practices and Discourses. Online. http://www.tandfonline.com/doi/full/10.1080/21693293.2016.1202903#abstract.

Plummer, R., Baird, J., Krievins, K., et al. (2016b). Improving river health: Initiating collaboration in a transboundary river basin. *International Journal of River Basin Management, 14*, 119–132.

Rockström, J., Falkenmark, M., Allan, T., et al. (2014). The unfolding water drama in the Anthropocene: Towards a resilience based perspective on water for global sustainability. *Ecohydrology, 7*(5), 1249–1261.

Rogers, P., & Hall, A. W. (2003). *Effective water governance* (TEC background papers, 7). Stockholm: Global Water Partnership.

Schoeman, J., Allan, C., & Finlayson, C. M. (2014). A new paradigm for water? A comparative review of integrated, adaptive and ecosystem-based water management in the Anthropocene. *International Journal of Water Resources, 30*(3), 377–390.

Simms, G., & de Loë, R. C. (2010). *Challenges for water governance in Canada: A discussion paper* (Governance for source water protection in Canada report no. 2). Waterloo: Water Policy and Governance Group.

Sprague, J. (2007). Great wet north? Canada's myth of water abundance. In K. Bakker (Ed.), *Eau Canada: The future of Canada's water* (pp. 23–36). Vancouver: UBC Press.

Walker, B., & Salt, D. (2006). *Resilience thinking: Sustaining ecosystems and people in a changing world*. Washington, DC: Island Press.

Walker, B., & Salt, D. (2012). *Resilience practice: Building capacity to absorb disturbance and maintain function*. Washington, DC: Island Press.

Wilkinson, C. (2012). Urban resilience: What does it mean in planning practice. *Planned Theory & Practice, 13*(2), 299–333.