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Reconciliation of Development and Ecosystems: The Ecology of Governance in the International Columbia River Basin

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ORIGINAL ARTICLE

Reconciliation of development and ecosystems: the ecology of governance in the International Columbia River Basin

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Abstract

This article explores the emergence of formal and informal bridging organizations to facilitate solutions to water conflict at the scale of the water resource. This new approach to governance is of particular importance on rivers within or shared by countries in which water management is fragmented among national and sub-national levels of government as well as among governmental sectors. This article focuses on the Columbia River Basin, in the United States and Canada. Review of the Columbia River Treaty governing shared management of the river has opened a public dialogue on river governance. Treaty review coincides with change in both the biophysical setting and the values and capacity of basin residents. Climate change is altering the timing of flow relied on by the management of developed river infrastructure and the annual runs of the basins' salmonid species. River development increased economic development in the basin, but at the cost of ecosystem function. Assertion of legal rights by indigenous communities has brought an alternative world view to the review—one that seeks to maintain the benefits of river development while reconciling that development with ecosystem function. This article identifies the governance mechanisms needed to achieve reconciliation and describes their emergence in the Columbia River Basin through an analytical framework focused on local capacity building and network formation across jurisdictions, sectors, and scales of governance. Both countries fragment water management authority among jurisdictions and sectors, but bridging organizations have emerged to link interests and government at the watershed and basin scale. Emergence of new governance is facilitated by increases in local, regional, and indigenous governance capacity. This networked governance emerging at the biophysical scale while embedded in and linked to a hierarchy of formal international, national, state, and local government is characterized as the ecology of governance.

Keywords Water governance · New environmental governance · Networked governance · Panarchy · International rivers · Columbia River Basin

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Introduction

Hydrologic systems and freshwater ecosystems have been altered throughout the world by an estimated 800,000 dams globally, with around 40,000 of those considered large dams (International Rivers 2007; Lehner et al. 2011). Dams have brought substantial economic growth to many regions of the world and, at the same time, substantial costs to ecosystem function (Poff et al. 2016). The need to invest in the aging river infrastructure of North America, built in the twentieth century (AWRA 2016; ASCE 2017), presents an opportunity to re-engineer these systems (Richter and Thomas 2007) and, in doing so, to reconcile development of rivers for human benefit with ecosystem function. This article asserts that reconciliation of development and ecosystem function at the scale of a river basin requires new forms of governance that can bridge sectors and jurisdictions to allow coordination at the scale of the resource or social-ecological system.

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Reconciliation means bringing differing views or systems into alignment and includes the notion that doing so may right past wrongs without restoring past conditions. In application to ecosystems, reconciliation captures the notion that many systems may have passed the point of restoration to "natural" conditions, yet are not beyond the point of improvement in ecosystem function (Barnosky et al. 2017; Benson and Craig 2017). Adding to the irreversibility of human alteration of ecosystem change is the observance that system change can be non-linear (Holling 1973; Walker and Salt 2006; Folke 2006), particularly when faced with the accelerating rates of change that characterize the Anthropocene (Steffen et al. 2007, 2011). Reconciliation ecology "is defined as the 'science of inventing, establishing, and maintaining new habitats to conserve species diversity in places where people live, work, and play'" (Moyle 2013 quoting Rosenzweig 2003, p. 7)—in short, the science of aligning human development within nature.

Reconciliation also captures the hope to align multiple ways of viewing nature and the transformation in social-ecological interaction that will require. The clash in world-views in modern water resource conflict is profound in regions with indigenous populations living with the legacy effects of colonization (Robison et al. 2018). One of the most critical divides in world views in this setting is the weight given to the measurable and quantifiable through Western science and economics versus that given to the intangible and qualitative, particularly the place of spirituality in resource management (LeBaron 2002; Wolf 2008). This divide is a recent product of eighteenth century Western Europe and remains common only within very specific geographic locales in the world (Martin 2007). Huston Smith, one of the premier scholars of the world's religions, eloquently states, "[t]he modern West is the first society to view the physical world as a closed system" (Smith 1993, p. 96). The idea of inherent balance between rationality and spirituality, self and community, rights and responsibilities, and mind and heart heavily underlies approaches to transforming conflicts in indigenous and spiritual communities around the world (Wolf 2008).

Reconciliation of development and ecosystem function has been considered in application to some of North America's most heavily developed freshwater systems (Moyle 2013).The Columbia River Basin (CRB) shared by Canada and the United States is in the midst of a review of the international treaty governing shared development and management of the river. Review of the Columbia River Treaty (Treaty) has led to the call for reconciliation of river development with ecosystem function reflecting both changing values, empowerment of local indigenous voices, and the reality that restoration to a prior state of nature is no longer possible or even desired by most. There is a growing recognition that reconciling ecosystem function with development as climate, population, and energy markets change will require increased adaptive capacity and governance that is responsive to change in the biophysical system. Similarly, the legacy of the western approach to problem solving and social-ecological interaction and the silencing of indigenous voices is profound in North America and is deeply felt as groups coalesce in dialogue in the CRB (Ogren 2015).

This article uses the CRB to illustrate how increased governance capacity among indigenous communities and emerging forms of new environmental governance may be effective in helping basin societies move toward reconciliation. In recent decades, the CRB has been locked in a polarized debate of hydropower versus salmon and development versus restoration, reflecting an assumption that re-engineering the system to explicitly take into account ecosystem function is impossible. As the USA and Canada commence negotiation of a new treaty on the Columbia River, the opportunity exists to reconcile the human and ecological system in ways not technologically possible in the twentieth century and in doing so also reconcile the two world views now engaging in the basin dialogue.

Analytical framework and methodology

This article evaluates the opportunity for reconciliation of a highly engineered river system with ecosystem function through analysis of emerging forms of water governance in the CRB. It applies aspects of two governance frameworks developed for managing complex environmental problems in the face of uncertainty and change to the CRB. The governance frameworks were developed through two projects with the NSF National Socio-Environmental Synthesis Center (SESYNC) in which two of the co-authors served as leads and are referred to as (1) the adaptive water governance project (Cosens et al. 2018) and (2) the networked governance project (Scarlett and McKinney 2016). "Governance" in the two frameworks refers to both the formal (governmental) and informal means through which society chooses collective goals, resolves conflict related to the environment, and takes actions to achieve those goals (Rogers and Hall 2003; Pelling et al. 2007; Delmas and Young 2009). Key aspects of each framework follow.

Adaptive water governance project

Adaptive governance is an observed, emergent form of environmental governance that is thought to be particularly suited to large scale social-ecological problems of environmental management such as reconciliation of water basin development and ecosystem function (Dietz et al. 2003; Karkkainen 2004; Brunner et al. 2005; Folke et al. 2005; Gunderson and Light 2006; Chaffin et al. 2014). The adaptive water governance project built on the work of scholars in ecological resilience who documented that ecosystems adapt to maintain structure and function up to a point, or threshold, in the face

of disturbance and may then cross into a new state from which it is more difficult to return (Holling 1973; Gunderson and Holling 2002; Walker et al. 2004; Walker and Salt 2006; Folke 2006). The project brought resilience scholars together with scholars who study legal and social systems with the goal of rethinking water management in light of this knowledge that systems may respond in a non-linear fashion to change (Cosens et al. 2018). The project results included identification of the role of law and government in facilitating the emergence of governance that is flexible, responsive to environmental change, and capable of navigating non-linear change (Cosens et al. 2017). In doing so, the project considered the legal mechanisms to ensure that flexibility in governance will not be achieved at the expense of social stability, legitimacy, equity, and justice (Craig et al. 2017; Cosens et al. 2017; Cosens and Williams 2012). Key aspects of the results of that project are relevant to this analysis: (1) the structure of government that will facilitate adaptive governance without destabilization and (2) the capacity of local and marginalized interests to participate in governance and the role of government in facilitating that capacity.

Adaptive water governance key element no. 1—governance structure Through the analysis of six North American water basins (Cosens et al. 2014), the project identified that while polycentric governance is important for adaptation and response to disturbance (Ostrom 2005, 1990; Dietz et al. 2003; Huitema et al. 2009), it is insufficient alone. Polycentric governance must include tight connections to feedback from the biophysical system in question through empowerment of local actors and yet act within a nested network of governance that provides resources, stability, and coordination at the scale of the system of interest (Cosens et al. 2017). Nesting of local decision making and innovation within higher levels of formal government provides a mechanism to check corruption, imposes uniform standards where appropriate, and provides financial and technical resources (Bingham 2010; Cosens et al. 2017).

Adaptive water governance key element no. 2—capacity Local governance capacity is essential to create the tight feedbacks necessary to enable responsiveness to change. Yet local actors often lack capacity (National Civic League 2013; Bingham 2009). Where capacity exists, it may be unevenly distributed and the result of distribution of authority to local levels may be to increase inequity. Thus, capacity building through the provision of financial and knowledge resources as well as institutional checks on power imbalance are roles for higher levels of government (Cosens et al. 2017).

Networked governance project

The networked governance project looked at the problem of managing landscapes that cross the boundaries of existing jurisdictions and institutions (Scarlett and McKinney 2016). The project looked at the role of civic entrepreneurs from both the public and private sectors, non-governmental organizations, and even universities as both bridging entities and catalysts for the emergence of a network of governance at the landscape scale (Kemmis and McKinney 2011). Networked structures emerge as organizations find that they cannot solve a particular problem or accomplish their goals by working alone (Scarlett and McKinney 2016).

The networked governance project turned to the literature on collaborative governance to understand networks as part of both the public and private response to complex problems that cross boundaries, whether those boundaries represent divides that are jurisdictional, sectoral, or the line between public and private resources (Carlsson and Sandstrom 2008; Leong et al. 2011; Emerson et al. 2011). The project was particularly interested in the democratic role of networks in catalyzing change (Wheatley and Frieze (2009), through enhancing the exchange of information, spreading risk, and increasing capacity (Carlsson and Sandstrom 2008). The project views the existence of bridging organizations and networks as a supplement to rather than a replacement of existing governance, and it is therefore compatible with other emerging new governance such as adaptive governance (Scarlett and McKinney 2016).

Integrated adaptive water governance and networked governance framework

Integrating the relevant findings from each project leads to a framework for analyzing both formal and informal governance that is emerging at the bioregional or landscape scale. Specifically, this approach seeks to identify and analyze: (1) capacity building within marginalized communities and the linkage between capacity and changes in policy and decision making relevant to the landscape in question and (2) governance mechanisms nested within and able to seek resources from a stabilizing government at a higher scale with bridging entities that are both emergent and those formally authorized to act at the bioregional scale.

Thus, the framework derived from the two projects focuses on the structure and linkage among both formal and informal governance. Panarchy is a concept used in ecological resilience theory to capture the nested, inter-connected, and hierarchical nature of ecosystems (Gunderson and Holling 2002) and provides a metaphor for the polycentric yet networked structure of governance necessary for adaptive capacity (Chaffin and Gunderson 2016). In both ecological and governance systems, panarchy captures the observation that interactions across scale may facilitate local innovation while providing the stability to experiment with low risk (Gunderson and Holling 2002; Chaffin and Gunderson 2016). Nevertheless, while panarchy captures the cross-scale

interactions and nested adaptive cycle observed among ecosystems, it is an imperfect fit for governance which is also influenced by agency and power (Olsson et al. 2015), factors important in the CRB study basin. We therefore use the phrase "ecology of governance" to capture the fact that we are relying on concepts with their roots in ecology but recognize the increasing complexity as we move to governance of social-ecological systems.

Approach to application of the integrated framework

This article applies the relevant aspects of the integrated analytical framework for the ecology of governance to a synthesis of research on the CRB (Table 1) under the umbrella of the Universities Consortium on Columbia River Governance (UCCRG). The authors have worked together since 2009 as the UCCRG to (1) facilitate a non-partisan forum for transboundary dialogue on CRB governance (UCCRG, n.d.), (2) connect university research to the needs of CRB constituents, and (3) prepare future leaders by engaging students in policy-relevant research. Formation of the UCCRG was catalyzed by the pending expiration of certain provisions of the Columbia River Treaty ("Treaty" described below) under which the United States and Canada share the benefits of hydropower production and utilization of dams for flood control. Through these activities, the authors engaged in participatory research and observation within the CRB as part of a basin-wide process of education and capacity building. The disciplinary backgrounds of the authors span hydrology, public policy, and law, but all share research and practice experience in conflict resolution. This article results from application of the integrated framework to information and understanding of the CRB developed through their engagement in research to understand the capacity of the CRB to adapt and transform and in participatory research in which they have sought to play a role in building that capacity (Ross and Berkes 2014). This analysis of the CRB and its emergent governance is, thus, from the perspective of synthesis of the results of participation and observation.

The International Columbia River Basin

The following paragraphs introduce the biophysical setting of the CRB, the history of human interaction with the basin culminating in international cooperation to produce hydropower and manage the risk of floods, the current structure of governmental water management in the basin, and the major changes in both the biophysical and social systems within the basin that are leading to new approaches to water basin governance. The article will conclude with analysis of the emerging forms of governance under the two elements of the integrated framework and their potential for facilitating reconciliation in the CRB. Figure 1 provides the current snapshot of the jurisdictional complexity of the basin and the locations of major river development.

The biophysical setting of the Columbia River Basin

The CRB located in the Pacific Northwest of the USA (85% of the basin area) and Canada (15% of the basin area) covers 671 billion square meters (an area roughly the size of France) (Fig. 1). Average annual flow is 247 billion cubic meters, but with its headwaters in the Rocky Mountains of Canada and the USA, flow is highly variable (Barton and Ketchum 2012). Spring snowmelt would result in an unregulated peak flow up to 34 times higher than late summer flow (Hamlet 2003). Pacific salmon have a 10 million-year history in the basin and have adapted to a geologically active region through strategies that have resulted in variable timing of runs from their adult life in the ocean to their natal streams to spawn (Waples et al. 2009; Healey 2009). Populations are estimated to have been as high as 12–15 million prior to European settlement (Hirt 2008).

Human interaction with the Columbia River Basin

Pacific salmon played a major role in the capacity of indigenous people to thrive in the CRB. Indigenous people made use of the natural variation by taking advantage of river morphology to harvest salmon, their primary protein source (Landeen and Pinkham 2008). Indigenous people used the annual runs used to mark time, and salmon played a large role in mythology (Hines 1999; Landeen and Pinkham 2008).

European colonization in the nineteenth century decimated indigenous populations through the introduction of disease and warfare (Josephy 1965) and the process of engineered alteration to the biophysical system began. Over fishing on a commercial scale led to the development of salmon hatcheries as early as 1866. Transformation of the river corridor began in 1896 with locks built for navigation by the U.S. Army Corps of Engineers (White 1995; Brooks 2006). In the 1930s, the US federal "New Deal" led to major public works projects to catalyze economic growth. In the CRB, major dams were developed for purposes of hydropower, irrigation, and flood control, culminating with international cooperation to develop and coordinate the management of dams for shared benefits from hydropower production and flood control (Columbia River Treaty 1964; Shurts 2012).

The structure of governmental management of water in the Columbia River Basin

The CRB is shared by two nations organized as states (USA) or provinces (Canada) united under their respective federal governments. The Columbia River is shared by seven US states (Washington, Oregon, Montana, and Idaho cover the majority

Table 1 Research and data collection on the Columbia River Basin (CRB) under the umbrella of the Universities Consortium on Columbia River Governance

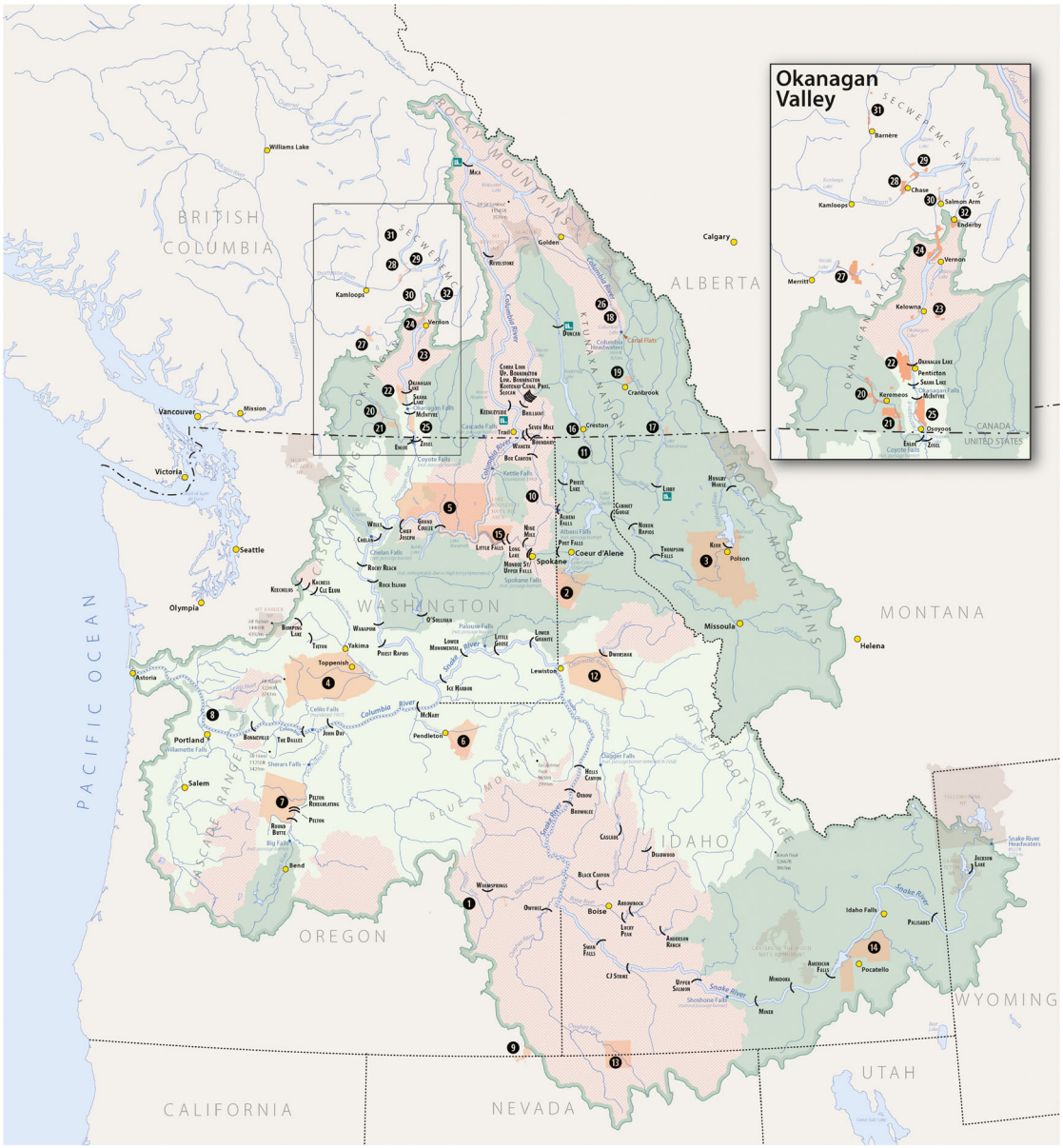
Short citation	Topic
Cosens (2012a) and Cosens and Williams (2012)	Analysis of the changes in the CRB since the USA and Canada entered into a treaty in 1964 for the sharing of hydropower and flood control benefits, including energy markets, climate, ecosystem function, and local and indigenous empowerment.
Bankes and Cosens (2012)	White paper to inform decision makers, sovereigns, and interests in the CRB on the domestic law of the USA and Canada relevant to their actions in and interpretation of international law.
Bankes and Cosens (2014)	White paper to inform decision makers, sovereigns, and interests in the CRB on existing international models for adaptive approaches to transboundary resource governance.
Paisley et al. (2015)	White paper to inform decision makers and sovereign entities in the CRB on existing models for participation of indigenous people in international river governance.
Cosens (2012c)	Legal/policy analysis of flood risk management in the CRB and opportunities for flexibility in river operation.
Cosens and Fremier (2014)	Resilience and governance assessment of the CRB.
Cosens (2016)	Opportunities for treaty modernization.
McKinney et al. (2010)	Graduate student situation assessment addressing review of the treaty and opportunities for collaboration.
Ogren (2015)	Graduate student evaluation of the process of treaty review by the USA and Canada.
Cecchini-Beaver (2013)	Graduate student development of a systems model for analysis of alternative CRB operational approaches.
Johnson (2016)	Graduate student analysis of flood risk management policy in the CRB including identification of opportunities for distributed risk management.
Timboe and Carter (2015)	Graduate student analysis of informal arrangements for transboundary cooperation in the CRB.
Weinman (2014)	Identification and mapping of watershed organizations in the CRB.

of the basin, with small portions in Nevada, Utah, and Wyoming) and one Canadian province (British Columbia). In the USA, water allocation is managed at the state level, whereas navigation, protection of endangered aquatic species, and much of the major water development for flood control, hydropower, and irrigation have been undertaken by the federal government (Cosens and Stow 2014). Most of the flood control and navigation infrastructure on the CRB was developed by the U.S. Army Corp of Engineers beginning in the 1930s, and irrigation dams were built by the U.S. Bureau of Reclamation. Dams under the control of both federal agencies produce hydropower along with private dams that are subject to federal licensing (U.S. Federal Power Act 16 USC 791a et seq.).

In Canada, provincial governments also have authority over water allocation but hold much of the authority over river development for navigation, hydropower, and flood control as well (Mouat 2012). Similar to the USA, the federal law in Canada addresses species at risk (Canada Species at Risk Act, S.C. 2002, c. 29). International cooperation financed development of the Columbia River in Canada.

Tribes (USA) and First Nations (Canada) also have rights and claims to water within the Columbia River Basin. The U.S. Supreme Court has recognized implied water rights associated with the purposes articulated in the documents establishing a reservation (Winters v. United States, 207 U.S. 564 (1908)). These "reserved" water rights have been recognized for, among other purposes, consumptive use for irrigated agriculture (Arizona v. California, 373 U.S. 546 (1963), instream uses for fisheries (United States v. Adair, 478 F. Supp. 336, 345–346 (D. Or. 1979), *aff'd* United States v Adair, 723 F.2d 1394 (9th Cir. 1983); Colville Confederated Tribes v. Walton, 647 F.2d 42, 48 (9th Cir. 1981)), and more broadly for any purpose necessary for a tribal homeland (*In Re* Gen. Adjudication of All Rights to Use Water in the Gila River Sys. & Source, 35 P.3d 68, 74 (Ariz. 2001)). Importantly for the Columbia River Basin, no court has yet considered whether instream flow rights are associated with off-reservation Treaty fishing rights on the mainstem of the Columbia River; nevertheless, the fishing rights are important to the role of tribes in fisheries management in the CRB and will be discussed below.

The Supreme Court of Canada did not reject the notion that the land did not belong to indigenous inhabitants prior to European settlement (i.e., the doctrine of terra nullius) until 1973 (Calder v. Attorney-General of British Columbia, S.C.R. 313 (1973), and the 1982 Constitution Act recognized the rights of First Nations to consultation concerning their



Tribal Nations in the United States*

1. Burns Paiute Tribe
2. Coeur d'Alene Tribe
3. Conf. Salish and Kootenai Tribes of the Flathead Nation
4. Conf. Tribes and Bands of the Yakama Nation
5. Conf. Tribes of the Colville Reservation
6. Conf. Tribes of the Umatilla Indian Res.
7. Conf. Tribes of the Warm Springs Res. of Oregon
8. Cowlitz Indian Tribe
9. Ft. McDermitt Paiute Shoshone Tribes
10. Kalispel Tribe of Indians
11. Kootenai Tribe of Idaho
12. Nez Perce Tribe
13. Shoshone Paiute Tribe of the Duck Valley Indian Res.
14. Shoshone-Bannock Tribes of the Ft. Hall Res.
15. Spokane Tribe of Indians

** management authorities and responsibilities affected by the Columbia River treaty; does not include all tribes in the Columbia Basin*

First Nations in Canada

Inside the Columbia Basin

KTUNAXA NATION

16. Yaqan nuʔkiy *(Lower Kootenay Indian Band)*
17. ʔakinkʷumtasnuqtiʔit *(Tobacco Plains Indian Band)*
18. ʔakisq̓nuk *(Columbia Lake Indian Band)*
19. ʔaq̓am *(St. Mary's Indian Band)*

OKANAGAN NATION

20. cʼəcʼəwixaʔ *(Upper Similkameen Indian Band)*
21. kɬkʼərʼmíws *(Lower Similkameen Indian Band)*
22. snpíntktn *(Penticton Indian Band)*
23. stqaʔtkʷəɬwt *(Westbank First Nation)*
24. suknaqínx *(Okanagan Indian Band)*
25. swíws *(Osoyoos Indian Band)*

SECWEPEMC NATION

26. Kenpésq̓t *(Shuswap Indian Band)*

Outside the Columbia Basin with Asserted Interests

OKANAGAN NATION

27. spaxomən *(Upper Nicola Band)*

SECWEPEMC NATION

29. Qwʔewt *(Little Shuswap Indian Band)*
28. Sexqeltqín *(Adams Lake Indian Band)*
31. Simpcw *(Simpcw First Nation)*
30. Sḱemtsin *(Neskanlith Indian Band)*
32. Splatsín *(Splatsin First Nation)*

This map was produced by the Columbia River Inter-Tribal Fish Commission. It is meant for informational and display purposes only and was created with the best data available at the time of production. It does not represent any legal boundaries or information.
Map date: October 2014

North
0 25 50 100 200 Kilometers
0 25 50 100 200 Miles

Columbia Basin Boundary
Area naturally inaccessible to salmon
Area rendered inaccessible to salmon
Reservation or Reserve
Dam authorized by Columbia River Treaty

◀ **Fig. 1** The Columbia River Basin, the outlines of the states with territory within its boundaries, the 15 Tribal nations with in the US portion of the basin, and the 17 First Nations with interests in the basin in British Columbia. The figure also illustrates the portion of the basin now blocked to salmon runs by dams without fish passage. Map and legend courtesy of the Columbia River Inter-Tribal Fish Commission

interests in land and water (British: Canada Constitution Act, Enacted as Schedule B to the *Canada Act, 1982* (U.K.) 1982 c. 35, which came into force on April 17, 1982). The recognition of First Nation water rights and land claims falls to the provinces, and this has not yet taken place in British Columbia. However, recent court rulings have made it clear that existence of a claim that is not yet formally recognized nevertheless triggers consultation (Tsilhqot'in Nation v. British Columbia, 2 S.C.R. 257 (2014)). In 1964, the Columbia River Treaty (Treaty) between the USA and Canada entered into force, leading to the development of dams in Canada for the shared benefits from hydropower production in the USA, as well as mutual benefits from flood control (Treaty). Prior to entry into force of the Treaty, the province of British Columbia held out for control and receipt of benefits under the Treaty (Mouat 2012); thus, the Province plays a much greater role in international management of the river than the US states.

Both before and as a result of the Treaty, formal governmental entities have been developed to address both subject specific and geographically specific issues that transcend jurisdictional boundaries in the CRB. In 1937, the Bonneville Power Administration (BPA) was established as a regional scale entity in the USA for the purpose of having a single entity that could coordinate the sale of hydropower from the federal dams in the Pacific Northwest (BPA, n.d.). In recent years, BPA has also managed what it refers to as "the largest fish and wildlife mitigation program in the nation, and perhaps in the world… to address the impacts of federal dams" (BPA 2013). Following entry into force of the Treaty, the USA appointed its representatives already involved in flood control and hydropower in the CRB—the Northwest Division manager of the Army Corps of Engineers and the Administrator of BPA—and British Columbia appointed its state owned hydropower entity—BC Hydro—as the operating entities under the Treaty. Together, the US and Canadian entities manage the river for hydropower and flood control (Barton and Ketchum 2012).

Two additional geographically based governmental organizations were established in the basin following entry into force of the Treaty, one in each country and both developed at least in part, in response to harm from the development of dams. In the USA, the Northwest Power Act of 1980 (Pacific Northwest Electric Power Planning and Conservation Act, Pub. L. No. 96–501, 94 Stat. 2697) authorized creation of the Northwest Power and Conservation Council (NWPCC) by compact among the CRB states of Washington, Oregon, Idaho, and Montana and composed of representatives from each state. The NWPCC was charged with energy and fisheries restoration planning (NWPCC, n.d.). With changes in energy markets in the wake of the oil embargo of the 1970s and decline in anadromous fish runs in the CRB, due in part to dams, it was initially thought that the NWPCC would resolve conflicts between energy production and the preservation of salmon runs. While the Northwest Power Act requires all actions of BPA to be consistent with the NWPCC electric power plan and BPA provides funding for mitigation consistent with the NWPCC fish and wildlife program, no authority is granted to the NWPCC or the BPA to reconcile the fish and wildlife program with hydropower operations in the basin by identifying tradeoffs between the two (Volkman and McConnaha 1993). Instead, basin residents led by CRB tribes sought listing of salmon populations under the U.S. Endangered Species Act in the 1990s. Nevertheless, the NWPCC plays a role as a bridging organization among states and engages in capacity building through education on issues including Treaty review.

In Canada, Columbia Basin Trust (CBT) was established in 1995 by the legislature of British Columbia. CBT was the result a grassroots effort to assert the rights of local communities and First Nations whose lands were flooded and livelihoods changed by Treaty dams (CBT, n.d.) It now receives hydropower revenue and is charged with water related education and economic development in those same communities and has played a major role in increasing community governance capacity and participation in issues such as the Treaty review.

Between 2010 and 2014, the basin communities participated in a substantial review of the Treaty led by the Army Corps of Engineers and BPA for the USA (U.S. Entity, n.d., 2013) and the province of British Columbia for Canada (British Columbia, n.d., 2013). Review was triggered by the anticipation of expiration of certain flood control measures in the Treaty in 2024, and the ability of either country to unilaterally terminate the treaty beginning in that year by giving 10 years notice (i.e., as early as 2014), but the review scope reflected much broader major changes in the basin since 1964 (Cosens 2012a).

Changes in the Columbia River Basin since entry into force of the international Columbia River Treaty

The region has experienced substantial economic growth since the Treaty entered into force in 1964, attributable in part to the availability of cheap electric power (Vogel 2012). At the same time, the infrastructure in the basin is aging, presenting an opportunity with review of the Treaty to solve other water-related issues. Key changes in the basin since 1964 that became important in the Treaty review include the following: change in anticipated energy demand, climate change impacts on water flow and timing, changes in ecosystem function, and evolving values and capacity among CRB residents.

Energy In 1964, it was anticipated that the continued growth in energy demand would lead to the development of thermal

power (i.e., nuclear) in the basin and value of the hydropower system would decline over time (White 1995). Instead, with the focus on conservation and the development of renewables, the hydropower system remains the core aspect of energy portfolios of US states in the region and has increased substantially in value (NWPCC 2016; Cosens 2012a).

Climate Changes in the basin's water supply are already observed and may be attributed to long-term climate change (Abatzoglou et al. 2014). Decline in snowpack (e.g., Mote et al. 2005), earlier runoff (e.g., Stewart et al. 2005; Hamlet et al. 2007), and reduction in annual flow (Luce and Holden 2009) are documented. These changes affect both the timing and the temperature of flow which may increase pressure on anadromous fish species as well as necessitate changes to operation of the hydropower and flood control system (Cosens et al. 2016).

Ecosystem function Thirteen populations of CRB salmon and steelhead are listed as either threatened or endangered under the U.S. Endangered Species Act, illustrating the substantial decline of wild anadromous fish runs in the basin (Code of Federal Regulations 50: § 223.102 2013; Federal Register 69: 33102, 33105 June 14, 2004; Federal Register 71: 5177, 5178 Feb. 1, 2006). Operation of the river to correspond with energy demand prevents the cool spring freshet from snowmelt runoff that once flushed juvenile salmon to the sea (Barton and Ketchum 2012). Adult salmon migration into Canada is blocked on the main stem of the river by dams in the USA built before the Treaty went into force with the knowledge that migration blockage would occur (Bottom et al. 2008). Dams without fish passage block at least 37% of the former spawning habitat (Harrison 2008) (Fig. 1). Fisheries within the basin were then engineered through the development of 178 hatcheries which now supply 80–90% of the anadromous fish runs (Hatchery Scientific Review Group 2009, 2014; Peery 2012; Goble 1999).

Biophysical changes since 1964 have catalyzed the demand for modernization of the Treaty and emerging changes in both formal and informal governance. Emerging governance processes in the CRB illustrate that a hierarchical and fragmented system of government may nevertheless set the stage for an emerging ecology of governance. In the following section, this article applies the analytical framework for the ecology of governance to consider the role of these emerging responses to the social-ecological complexity of river basin governance in moving toward reconciliation of a highly developed river system with ecosystem function.

Reconciliation and the ecology of governance

Application of the integrated framework for adaptive and networked governance to the CRB reveals (1) increase in governance capacity of indigenous communities that is influencing decision making at the local and basin scales and (2) emergence of polycentric governance organized and connected through formal and informal bridging entities and nested across multiple biophysical scales. This section uses the framework to organize the emergence of new voices and approaches to governance in the CRB beginning with the increase in local capacity followed by the emergence of informal governance at the biophysical scale. We will follow this analysis with discussion of the efficacy of their potential to facilitate reconciliation of development with ecosystem function.

Building governance capacity

In 1964, local basin communities and indigenous peoples possessed little capacity to participate in basin governance. Today, that is changing (Cosens 2012b, Cosens 2016). The story of the rise of indigenous voices in the CRB can be framed as a legal battle followed by capacity building or as a clash of world views followed by the possibility of transformation. Neither story is complete without the other so the following paragraphs begin with the legal battle; it continues to the differing world views and the capacity of federal legal and governance systems to mediate their clash.

Legal recognition of indigenous treaty fishing rights in federal court provided the foundation for capacity building that elevated certain of the Tribes in the US portion of the CRB to status as co-managers of the basin's fisheries (United States v. Washington 1974; Washington v. Washington State Commercial Passenger Fishing Vessel Association 1979). The four tribal nations (Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and Confederated Tribes and Bands of the Yakama Nation) involved in the litigation organized as the Columbia River Inter-Tribal Fish Commission and have developed a highly sophisticated science and policy agency engaging in restoration of salmon, lamprey, and sturgeon and managing Tribal harvest allocation on the river (Columbia River Inter-Tribal Fish Commission n.d.; Cosens 2012b). Upper-basin tribes within the USA whose land was blocked from anadromous fish migration organized as the Upper Columbia United Tribes (UCUT n.d.). In 2005, UCUT and its member Tribes entered a memorandum of understanding with BPA recognizing the sovereign role of the Tribes in management of, among other things, fish and water resources and providing access to BPA's mitigation fund for their restoration activities (UCUT 2005).

Although Tribes and First Nations had no voice in negotiation of the original Treaty, with this increased capacity, all 15 tribes in the US portion of the CRB came together to develop a common position in the Treaty review seeking recognition of cultural and ecological values and their sovereign rights (Columbia Basin Tribes 2010). The 15 tribes then joined together to select five representatives to the Sovereign Review

Team invited to advise the US regional review process (U.S. Entity, n.d.). The federal agencies leading the regional review for the USA were under no legal obligation to establish a forum for tribal and state input; thus, their decision to do so suggests the recognition of the growth of local power and capacity in the basin and the reality that no political solution will be possible without this input. The power of speaking with one voice and the paradigm shift in the acceptance of tribes as sovereigns is illustrated in the result of the regional review which recommends the elevation of ecosystem function to a third prong of the Treaty (U.S. Entity 2013), a position brought to the table by the 15 U.S. tribes (Columbia Basin Tribes 2010). While the Canadian First Nations have yet to formally coalesce to the same degree as the tribes in the USA, they have also sought participation in any future Treaty negotiation and have achieved some progress in the legal recognition of their land and water rights (Canadian Charter of Rights and Freedoms, Part II Sec. 35 of the Constitution Act, Tsilhqot'in Nation v. British Columbia 2014).

While review of the Treaty on the US side of the border led to the recommendation to elevate ecosystem function to a third prong of a modernized treaty alongside hydropower and flood control (U.S. Entity 2013), the decision following review by the government of British Columbia acknowledged the importance of ecosystem function but questioned its elevation to the international level (British Columbia 2013). In a study on governance mechanisms, UCCRG members assert that it may be possible to accommodate both views through a more sophisticated approach to governance structure that does not elevate all issues to the international level (Bankes and Cosens 2014). Flow and aspects of water quality (in particular temperature) are strongly influenced by international operation of the river and thus appropriately addressed in an international agreement. In contrast, habitat modification and restoration raise local issues while posing cumulative effects that are basin-wide. Nesting governance of local issues within the federal systems of two the countries and coordination through an international instrument might achieve both the US and BC goals. It is in this aspect that the emergence of watershed scale governance is important.

Emergent governance: nesting and bridging

At the smallest biophysical scale, approximately 150 multi-stakeholder watershed groups have developed in the CRB (Weinman 2014). Their formation has generally been initiated by citizens, but includes participation by local, state/provincial, and federal government agencies. In some cases, federal or state legislation provided a framework and financial incentives for their development (see, e.g., U.S. Clean Water Act: Federal Water Pollution Control Amendments of 1972, P.L. 92–500). Although the purpose and scope of these organizations vary, all provide forums for information exchange, capacity building, and joint problem solving (Weinman 2014).

The Blackfoot Challenge on the Blackfoot River watershed in the CRB headwaters of Montana (Blackfoot Challenge, n.d.) (Fig. 2) provides an example of the watershed scale non-governmental organization. The organization was catalyzed by conflict among those interested in resource development and those interested in its protection (Blackfoot Challenge, n.d.). The informal membership includes private and corporate landowners, federal and state land managers, and local government officials and coordinates management of the watershed as a rural working landscape with attention to livelihoods as well as conservation (Blackfoot Challenge, n.d.). The Blackfoot Challenge has been recognized nationally as a model for preserving the rural character, ecological health, and natural beauty of a watershed (Nambisan 2008). It has had success in integrated weed management, drought planning that includes cooperative efforts to maintain instream flows, stream and riparian corridor restoration, removal of barriers to fish passage, the use of legal tools (conservation easements) to preserve working landscapes, and community education including involvement of schools within the watershed (Blackfoot Challenge, n.d.). The Blackfoot Challenge illustrates how watershed organizations "nest" alongside each other and within the larger CRB context. The informal network created among actors within or influencing the watershed management serves as a bridge connecting the fragmented natural resource management at the watershed scale. Although not formally connected to these efforts, formal bridging organizations including the NWPCC and the CBT discussed above could be authorized to enhance communication and coordination across these watershed scale entities toward a goal of reconciliation.

Discussion

The combined effect of over 50 years of river development transformed the CRB ecosystem and provides a setting in which to study the potential for reconciliation of a developed river with ecosystem function. In analyzing the emerging voices and governance in the CRB, it is thus useful to return to this initial concept of reconciliation and inquire into the efficacy of these new forms of governance in achieving that goal. While impossible to answer, some light can be shed by considering the potential causes of emergence of new environmental governance. As noted above, the authors engaged in participatory research and observation within the CRB as part of a basin-wide process of education and capacity building. This discussion is, thus, from the perspective of synthesis of the results of participation and observation and includes knowledge the authors have acquired from the people of the

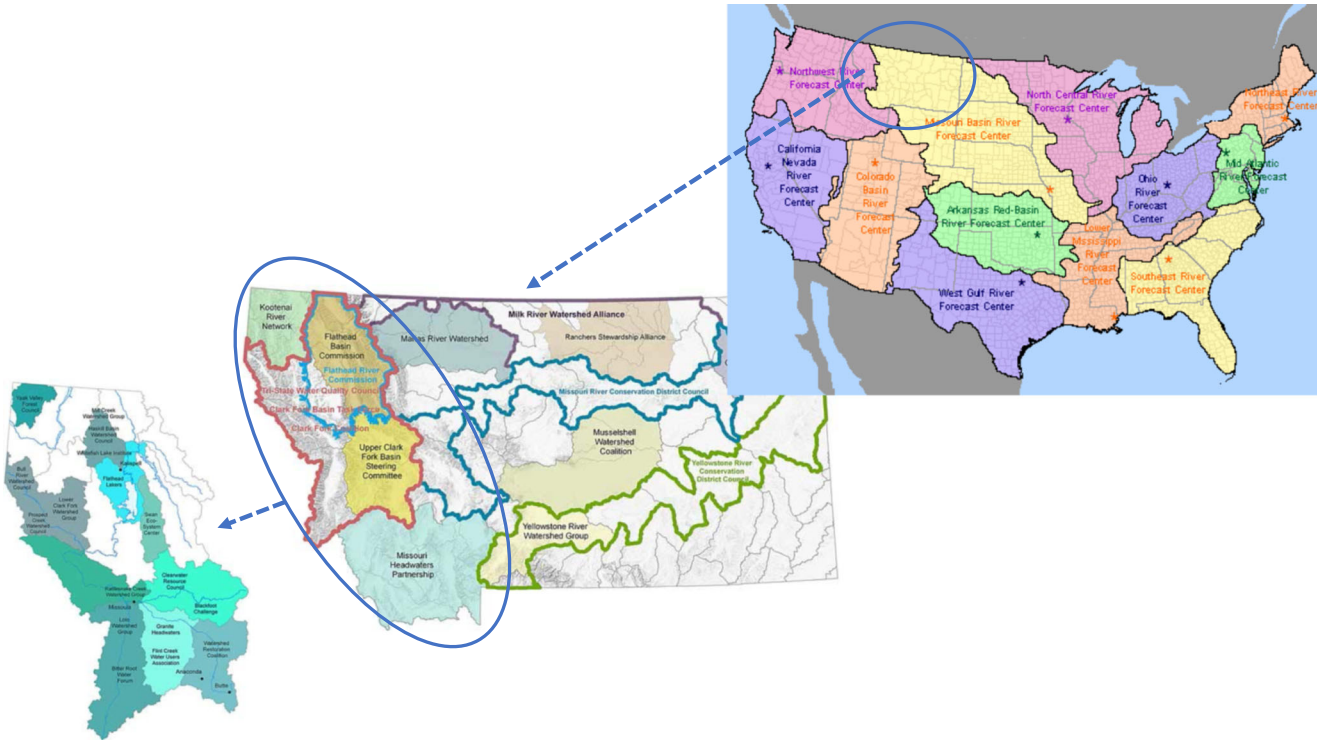


Fig. 2 Nesting of watershed organizations within federal system illustrated for the State of Montana. The map of the USA (source: Earth System Laboratory at NOAA. URL: http://www.wrsc.org/attach_image/us-river-basins) shows the federal forecasting centers associated with major water basins superimposed on state and county (local government level) boundaries. The map in the center of Montana (source: Montana Watershed Coordination Council n.d., URL: http://mtwatersheds.org/app/watershed-map/) shows the watershed organizations active at the large watershed scale. The map in the lower left (source: Montana Watershed Coordination Council n.d., URL: http://mtwatersheds.org/app/watershed-map/) shows the smaller scale watershed organizations within the portion of Montana in the Columbia River Basin

CRB. This participatory approach to research may result in a more normative synthesis than obtained with a more detached methodology.

The ecology of governance in the transboundary CRB is illustrative of a trend in natural resource policy where citizens and non-governmental organizations or associations are increasingly taking the lead to convene, coordinate, and implement actions to solve environmental problems, whether related to resource allocation, conservation, or stewardship. This trend not only suggests a shift from an expert-driven model of politics to more democratic approaches but also raises some important questions about governance within a fragmented system and the role of citizens, professionals, and communities in governance.

The ecology of governance in the CRB seems to be evolving for three reasons. The first reason is perhaps obvious and easy to understand—the formal systems for public engagement and decision-making alone are simply inadequate for the task at hand. The mission and mandate of the Treaty, for example, is limited to flood risk management and hydropower production and has no mandate to address many of the other issues around which people have organized at the watershed and transboundary scale, and does not include a means for evolution over time. This is fueled by the evolution in what society wants from a river basin or large landscape—a list based on conflicting values that is seemingly more complicated today than it was in the past simply because of the diversity of voices at the table. While the USA has long identified as a multicultural society, it is only in the past 50 years (since the Columbia River Treaty entered into force) that capacity building has given voice to the most diverse members of our communities whose values were not reflected in river development.

The second reason for the emergence of the ecology of governance is in response to the limitations of the existing system of politics and governance to employ an approach tailored to a specific place. In its absence, people are forging a system of civic engagement and public problem solving that more appropriately fits the region. The ecology of governance emerging in the CRB is self-organizing, rooted in a deep sense of place, and nested—from very local watershed groups to sub-basin entities to transboundary and basin-wide organizations—from governmental entities strictly held within legal bounds—to informal transboundary communities. While not all of the initiatives explained earlier have formal authority to make and implement decisions, they each play a critical role in exchanging information, building relationships, and exploring opportunities to work together. As an organic, emergent system of governance, they help build the civic and political will

to address complex land, water, and natural resources issues in the CRB that cannot be effectively addressed by any single community, stakeholder group, or government agency.

The third reason is that the path dependencies created by mid-twentieth century river development means that any effort to reconcile development with ecosystem function will require not only a dialogue on tradeoffs but also investment at least at the level of the original dam building. The resource commitment required is not likely without the political power of the basin as a whole behind it. No traditional science-based decision making process is likely to achieve this goal.

It must be acknowledged that resort to emergent governance while providing avenues for more inclusive and tailored process provides no guarantee that the outcome will be reconciliation of developed systems with ecosystem function or even anything resembling a sustainable social-ecological system. But as illustrated by the ongoing battle of dams versus salmon in the CRB, sustainable solutions are seemingly impossible under traditional governance and existing infrastructure and while new approaches pose some risk, if implemented cautiously with a learning-by-doing approach, they may be less risky than doing nothing. It must also be recognized that with the slow process of institutional evolution and the current backlash in the USA against environmental values and multiculturalism, these emerging forms of new environmental governance in the CRB may not lead to their institutionalization at the national or international scale in the short term. Nevertheless, in the complex interaction between law and society, informal systems today plant the seeds for future transformation.

Conclusion

The term ecology of governance describes new forms of adaptive and networked governance that emerge in response to a problem at the bioregional scale. This emerging governance is not the vision or brainchild of any one person or group, and it is also possible that it is facilitated by formal governance in which multiple scales of engagement and democratic values are already the norm. In the final analysis, the pragmatic approach emerging in the Columbia River Basin and other transboundary river basins throughout the world is not either/or (i.e., either formal or informal systems of governance), but both. Sustainability of social-ecological systems in the face of change requires governance that facilitates recapture of key aspects of ecosystem function, yet sustainability of those same systems requires continuation of economies based on development of natural systems. It is time that we focused both our governance and development of technology in reconciling these seemingly conflicting goals.

Acronyms

BPA	Bonneville Power Administration
CBT	Columbia Basin Trust
CRB	Columbia River Basin
CRITFC	Columbia River Inter-Tribal Fish Commission
NWPCC	Northwest Power and Conservation Council
SESYNC	National Socio-Environmental Synthesis Center
UCCRG	Universities Consortium on Columbia River Governance
UCUT	Upper Columbia United Tribes

References

Abatzoglou J, Rupp DE, Mote PW (2014) Understanding seasonal climate variability and change in the Pacific Northwest of the United States. J Clim 27:2125–2142. https://doi.org/10.1175/JCLI-D-13-00218.1

ASCE, American Society of Civil Engineers (2017) Infrastructure report card. Available at: https://www.infrastructurereportcard.org/

AWRA, American Water Resources Association (2016) Ensuring sustainable funding for water-resource infrastructure. Policy statement. Available at: http://www.awra.org/policy/policy-statements-infrastructure.html

Bankes N, Cosens B (2012) The future of the Columbia River Treaty, research project for the program on water issues, Munk School of Global Affairs, University of Toronto, available at http://munkschool.utoronto.ca/research/the-future-of-the-columbia-river-treaty/

Bankes N, Cosens B (2014) Protocols for adaptive water governance: the future of the Columbia River Treaty, October 21, 2014, research project for the program on water issues, Munk School of Global Affairs, University of Toronto. http://powi.ca/wp-content/uploads/2014/10/Protocols-for-Adaptive-Water-Governance-Final-October-14-2014.pdf

Barnosky AD, Hadly EA, Gonzalez P, Head J, Polly PD, Lawing AM, Eronen JT, Ackerly DD, Alex K, Biber E, Blois J, Brashares J, Ceballos G, Davis E, Dietl GP, Dirzo R, Doremus H, Fortelius M, Greene HW, Hellmann J, Hickler T, Jackson ST, Kemp M, Koch PL, Kremen C, Lindsey EL, Looy C, Marshall CR, Mendenhall C, Mulch A, Mychajliw AM, Nowak C, Ramakrishnan U, Schnitzler J, Shrestha KD, Solari K, Stegner L, Stegner MA, Stenseth NC, Wake MH, Zhang Z (2017) Merging paleobiology with conservation biology to guide the future of terrestrial ecosystems. Science 355:594. https://doi.org/10.1126/science.aah4787

Barton J, Ketchum K (2012) Columbia River treaty: managing for uncertainty. In: Cosens B (ed) The Columbia River treaty revisited: transboundary river governance in the face of uncertainty. Oregon State University Press, Corvallis

Benson MH, Craig RK (2017) The end of sustainability: resilience and the future of environmental governance in the Anthropocene. University of Kansas Press, Lawrence

Bingham LB (2009) Collaborative governance: emerging practices and the incomplete legal framework for public and stakeholder voice. J Disput Resolut 2(2):1–58

Bingham LB (2010) The next generation of administrative law: building the legal infrastructure for collaborative governance. Wisconsin Law Rev 2:297–356

Blackfoot Challenge. (n.d.) http://www.blackfootchallenge.org/

Bottom DL, Jones KK, Simenstad CA, Smith CL e (2008) Special issue on pathways to resilient salmon ecosystems. Ecol Soc 14(1):34. https://doi.org/10.5751/ES-02734-140105

BPA (2013) Bonneville Power Administration Fact Sheets https://www.bpa.gov/news/pubs/FactSheets/fs-201305-BPAs-Fish-and-Wildlife-Program-the-Northwest-working-together.pdf

BPA (n.d.) Bonneville Power Administration, About Us https://www.bpa.gov/news/AboutUs/Pages/default.aspx

British Columbia (2013) Columbia River Treaty review: B.C. decision. http://blog.gov.bc.ca/columbiarivertreaty/files/2012/03/BC_Decision_on_Columbia_River_Treaty.pdf

British Columbia. (n.d.) Columbia River Treaty review. http://blog.gov.bc.ca/columbiarivertreaty/

Brooks KB (2006) Public power, private dams: the hell's canyon high dam controversy. University of Washington Press

Brunner RD, Colburn CH, Cromley CM, Klein RA, Olson EA (eds) (2005) Adaptive governance: integrating science, policy, and decision making. Columbia University Press

Carlsson L, Sandstrom A (2008) Network governance of the commons. Int J Commons 2(1):33–54

CBT (n.d.) Columbia Basin Trust. About Us. https://ourtrust.org/about/our-story/

Cecchini-Beaver M (2013) Transboundary Columbia River operational alternative analysis in a collaborative framework. M.S. Thesis University of Idaho Water Resources Program, available from co-author Cosens

Chaffin BC, Gunderson LH (2016) Emergence, institutionalization and renewal: rhythms of adaptive governance in complex social-ecological systems. J Environ Manag 165:81–87. https://doi.org/10.1016/j.jenvman.2015.09.003

Chaffin BC, Gosnell H, Cosens B (2014) A decade of adaptive governance scholarship: synthesis and future directions. Ecol Soc 19(3):56. https://doi.org/10.5751/ES-06824-190356

Columbia Basin Tribes (2010) Common views on the future of the Columbia River Treaty. http://www.usea.org/sites/default/files/event-/Common%20Views%20statement%20NQ.pdf

Columbia River Inter-Tribal Fish Commission. (n.d.) http://www.critfc.org/

Columbia River Treaty (Treaty) (1964) Treaty between the United States of America and Canada relating to cooperative development of the water resources of the Columbia River Basin, U.S.-Can., Jan 17, 1961, 152 UST 1555

Cosens B (ed) (2012a) The Columbia River Treaty revisited: transboundary river governance in the face of uncertainty. Oregon State University Press, Corvallis

Cosens B (2012b) Changes in empowerment: rising voices in Columbia basin resource management. In: Cosens B (ed) The Columbia River Treaty revisited: transboundary river governance in the face of uncertainty. Oregon State University Press, Corvallis

Cosens B (2012c) Resilience and law as a theoretical backdrop for natural resource management: flood management in the Columbia River Basin. Environ Law 42:241–264

Cosens B (2016) The Columbia River Treaty: an opportunity for modernization of basin governance. Colorado Nat Resour Energy Environ Law Rev 27(1): 1–19, available at http://www.colorado.edu/law/sites/default/files/CNREELR-V27-I1-Cosens%20Final_0.pdf

Cosens B, Fremier A (2014) Assessing system resilience and ecosystem services in large river basins: a case study of the Columbia River Basin. Nat Resour Environ Law Ed Idaho Law Rev 51:91–125

Cosens B, Stow C (2014) Resilience and water governance: addressing fragmentation and uncertainty in water allocation and water quality law. In: Garmestani A, Allen C (eds) Social-ecological resilience and law. Columbia University Press

Cosens BA, Williams MK (2012) Resilience and water governance: adaptive governance in the Columbia River Basin. Ecol Soc 17(4):3. https://doi.org/10.5751/ES-04986-170403

Cosens B, Gunderson L, Chaffin B (2014) The adaptive water governance project: assessing law, resilience and governance in regional socio-ecological water systems facing a changing climate. Nat Resour Environ Law Ed Idaho Law Rev 51(1):1–27

Cosens B, Fremier A, Bankes N, Abatzoglou J (2016) The Columbia River Treaty and the dynamics of transboundary water negotiations in a changing environment: how might climate change alter the game? In: Miller K, Hamlet A, Kenny D, Redmond K (eds) Chapter 10 in Water policy and planning in a variable and changing climate. CRC Press

Cosens BA, Craig RK, Hirsch S, Arnold C, Benson MH, DeCaro DA, Garmestani AS, Gosnell H, Ruhl J, Schlager E (2017) The role of law in adaptive governance. Ecol Soc 22(1):30. https://doi.org/10.5751/ES-08731-220130

Cosens B, Gunderson L, Chaffin B (2018) Introduction to the special feature practicing panarchy: assessing legal flexibility, ecological resilience and adaptive governance in regional water systems experiencing rapid environmental change. Ecol Soc 23(1):4. https://doi.org/10.5751/ES-09524-230104

Craig RK, Garmestani AS, Allen CR, Arnold CA, Birgé H, DeCaro DA, Fremier AK, Gosnell H, Schlager E (2017) Balancing stability and flexibility in adaptive governance: an analysis of tools available in U.S. environmental law. Ecol Soc 22(2):3. https://doi.org/10.5751/ES-08983-220203

Delmas MA, Young OR (eds) (2009) Governance for the environment: new perspectives. Cambridge University Press

Dietz T, Ostrom E, Stern PC (2003) The struggle to govern the commons. Science 302:1907–1912. https://doi.org/10.1126/science.1091015

Emerson K, Nabatchi T, Balogh S (2011) An integrative framework for collaborative governance. J Public Adm Res Theory 22(1):1–29. https://doi.org/10.1093/jopart/mur011

Folke C (2006) Resilience: the emergence of a perspective for social–ecological systems analyses. Glob Environ Chang 16:253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002

Folke C, Hahn T, Olsson P, Norberg J (2005) Adaptive governance of social-ecological systems. Ann Rev Environ Resour 30:441–473. https://doi.org/10.1146/annurev.energy.30.050504.144511

Goble DD (1999) Salmon in the Columbia Basin: from abundance to extinction. In: Goble DD, Hirt PW (eds) Northwest lands, northwest peoples: readings in environmental history. University of Washington Press

Gunderson L, Holling CS (eds) (2002) Panarchy: understanding transformations in human and natural systems. Island Press, Washington D.C

Gunderson LH, Light SS (2006) Adaptive management and adaptive governance in the everglades ecosystem. Policy Sci 39:323–334. https://doi.org/10.1007/s11077-006-9027-2

Hamlet AF (2003) The role of transboundary agreements in the Columbia River basin: an integrated assessment in the context of historic development, climate, and evolving water policy. In: Diaz HF, Morehouse BJ (eds) Climate and water: transboundary challenges in the Americas. Kluwer, Dordrecht

Hamlet AF, Mote PW, Clark MP, Lettenmaier DP (2007) 20th century trends in runoff, evapotranspiration, and soil moisture in the Western U.S. J Clim 20:1468–1486. https://doi.org/10.1175/JCLI4051.1

Harrison, J. (2008) Northwest Power and Conservation Council, Fish passage at dams. http://www.nwcouncil.org/history/fishpassage

Hatchery Scientific Review Group (2009) Columbia River System—wide report. http://hatcheryreform.us/reports/columbia-river/system-wide-report/

Hatchery Scientific Review Group (2014) On the science of hatcheries: an updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest. https://wdfw.wa.gov/about/advisory/crag/documents/hsrg_science_hatcheries_june_2014.pdf

Healey MC (2009) Resilient salmon, resilient fisheries for British Columbia, Canada. Ecol Soc 14(1):2. https://doi.org/10.5751/ES-02619-140102

Hines DM (1999) The maiden and salmon. In: Tales of the Nez Perce. Ye Galleon Press, Fairfield

Hirt PW (2008) Developing a plentiful resource: transboundary rivers in the Pacific Northwest. In: Whiteley JM, Ingram H, Perry R (eds) Water, place, and equity. MIT Press, Cambridge, pp 147–188

Holling CS (1973) Resilience and stability of ecological systems. Annu Rev Ecol Syst 4:1–24. https://doi.org/10.1146/annurev.es.04.110173.000245

Huitema D, Mostert E, Egas W, Moellenkamp S, Pahl-Wostl C, Yalcin R (2009) Adaptive water governance: assessing the institutional prescriptions of adaptive (co) management from a governance perspective and defining a research agenda. Ecology and Society 14(1): 26. URL: http://www.ecologyandsociety.org/vol14/iss1/art26/

International Rivers (2007) Damming statistics https://www.internationalrivers.org/damming-statistics

Johnson P (2016) A comprehensive integrated water resource assessment of potential changes to Columbia River basin flood risk management policy. M.S. Thesis. University of Idaho Water Resources Program, available from co-author Cosens Josephy, A. (1965) The Nez Perce Indians and the Opening of the Northwest. Yale, New Haven, Connecticut, USA

Karkkainen BC (2004) "New governance" in legal thought and in the world: some splitting as antidote to overzealous lumping. Minnesota Law Rev 89:471–497

Kemmis D, McKinney M (2011) Collaboration and the ecology of democracy. Kettering Foundation, Dayton

Landeen D, Pinkham A (2008) Salmon and his people: fish and fishing in Nez Perce culture. Confluence Press, Lewiston

LeBaron M (2002) Bridging troubled waters: conflict resolution from the heart. Jossey-Bass, San Francisco

Lehner B, Reidy Liermann C, Revenga C, Vörösmart C, Fekete B, Crouzet P, Döll P, Endejan M, Frenken K, Magome J, Nilsson C, Robertson JC, Rodel R, Sindorf N, Wisser D (2011) High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management. Front Ecol Environ 9:494–502. https://doi.org/10.1890/100125

Leong KM, Emmerson DP, Byron R (2011) The new governance: implications for collaborative conservation and adaptive management in Department of the Interior agencies. Hum Dimens Wildl 16(4):236–243. https://doi.org/10.1080/10871209.2011.585436

Luce CH, Holden ZA (2009) Declining annual streamflow distributions in the Pacific Northwest United States, 1948–2006. Geophys Res Lett 36:1–6. https://doi.org/10.1029/2009GL039407

Martin D (2007) The religious and the secular: pressure points and alignments (Keynote address, Forum 2000 Conference: Freedom and Responsibility, Prague: 8 October 2007)

McKinney M, Baker L, Buvel AM, Fischer A, Foster D, Paulu C (2010) Managing transboundary natural resources: an assessment of the need to revise and update the Columbia River Treaty. West-Northw J Environ Law Policy 16(2):307–350

Montana Watershed Coordination Council (n.d.) http://mtwatersheds.org/app/watershed-map/

Mote P, Hamlet A, Clark MP, Lettenmaier DP (2005) Declining mountain snowpack in Western North America. Bull Am Meteorol Soc 86:39–49. https://doi.org/10.1175/BAMS-86-1-39

Mouat M (2012) The Columbia exchange: a Canadian perspective on the negotiation of the Columbia River Treaty. In: Cosens B (ed) The Columbia River treaty revisited: transboundary river governance in the face of uncertainty. Oregon State University Press, Corvallis

Moyle PB (2013) Novel aquatic ecosystems: the new reality for streams in California and other Mediterranean climate regions. River Res Appl 30:1335–1344. https://doi.org/10.1002/rra.2709

Nambisan S (2008) Transforming government through collaborative innovation. Public Manager 37(3):36–41

National Civic League (NCL) (2013) Making public participation legal. [online] http://ncdd.org/rc/wp-content/uploads/MakingP2Legal.pdf

NWPCC (2016) Northwest Power and Conservation Council, February 10, 2016, Seventh Power Plan. https://www.nwcouncil.org/energy/powerplan/7/plan/

NWPCC (n.d.) Northwest Power and Conservation Council. URL: https://www.nwcouncil.org/

Ogren K (2015) Water governance process assessment: evaluating the link between decision making processes and outcomes in the Columbia River Basin. Oregon State University, unpublished PhD dissertation. https://ir.library.oregonstate.edu/xmlui/handle/1957/56887

Olsson L, Jerneck A, Thoren H, Persson J, O'Byrne D (2015) Why resilience is unappealing to social science: theoretical and empirical investigations of the scientific use of resilience. Sci Adv 2015:1–11. https://doi.org/10.1126/sciadv.1400217

Ostrom E (1990) Governing the commons: the evolution of Institutions for Collective Action. Cambridge University Press

Ostrom E (2005) Understanding institutional diversity. Princeton University Press, Princeton

Paisley RK, McKinney MJ, Stenovec MS (2015) A sacred responsibility: governing the use of water and related resources in the International Columbia Basin through the Prism of Tribes and First Nations. http://www.columbiarivergovernance.org/A_Shared_Responsibility_2015_FINAL.pdf

Peery C (2012) The effects of dams and flow management on Columbia River ecosystem processes. In: Cosens B (ed) The Columbia River Treaty revisited: transboundary river governance in the face of uncertainty. Oregon State University Press

Pelling M, High C, Dearing J, Smith D (2007) Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organisations. Environ Plan A 40(4):867–884. https://doi.org/10.1068/a39148

Poff NL, Brown CM, Grantham TE, Matthews JH, Palmer MA, Spence CM, Wilby RL, Haasnoot M, Mendoza GF, Dominique KC, Baeza A (2016) Sustainable water management under future uncertainty with eco-engineering decision scaling. Nat Clim Change 6:25–34. https://doi.org/10.1038/NCLIMATE2765

Robison J, Cosens B, Jackson S, Leonard K, McCool D (2018) Indigenous water justice. Lewis and Clark Law Review 22. (forthcoming)

Rogers P, Hall A (2003) Effective water governance. Global Water Partnership Technical Committee (TEC) background paper 7. Global Water Partnership, Stockholm. http://www.gwp.org/Global/ToolBox/Publications/Background%20papers/07%20Effective%20Water%20Governance%20%282003%29%20English.pdf

Rosenzweig ML (2003) Win-win ecology: how the Earth's species can survive in the midst of human enterprise. Oxford University Press, Oxford

Ross H, Berkes F (2014) Research Approaches for understanding, enhancing, and monitoring community sesilience. Soc Nat Resour 27: 787–804. https://doi.org/10.1080/08941920.2014.905668

Scarlett L, McKinney M (2016) Connecting people and places: the emerging role of network governance in large landscape conservation. Front Ecol Environ 14(3):116–125. https://doi.org/10.1002/fee.1247

Shurts J (2012) Rethinking the Columbia River Treaty. In: Cosens B (ed) The Columbia River Treaty revisited: transboundary river governance in the face of uncertainty. Oregon State University Press, Corvallis

Smith H (1993) Forgotten Truth: The common vision of the world's religions. Harper Collins Publishing, San Francisco

Steffen W, Crutzen PJ, McNeill JR (2007) The Anthropocene: are humans now overwhelming the great forces of nature? Ambio

36(8):614–621. https://doi.org/10.1579/0044-7447(2007)36[614:TAAHNO]2.0.CO;2

Steffen W, Persson Å, Deutsch L, Zalasiewicz J, Williams M, Richardson K, Crumley C, Crutzen P, Folke C, Gordon L, Molina M, Ramanathan V, Rockström J, Scheffer M, Schellnhuber HJ, Svedin U (2011) The anthropocene: from global change to planetary stewardship. Ambio 40:739–761. https://doi.org/10.1007/s13280-011-0185-x

Stewart IT, Cayan DR, Dettinger MD (2005) Changes toward earlier streamflow timing across Western North America. J. Climate 18: 1136–1155. https://doi.org/10.1175/JCLI3321.1

Timboe I, Carter M (2015) Transboundary cooperation in the International Columbia River Basin: a preliminary assessment of existing arrangements and future prospects Available from co-author Dr. Matthew McKinney.

U.S. Entity (2013) Regional recommendation for the future of the Columbia River Treaty after 2024. http://www.crt2014-2024review.gov/Files/Regional%20Recommendation%20Final,%2013%20DEC%202013.pdf.

U.S. Entity (n.d.) Columbia River Treaty 2014/2024 Review. https://www.bpa.gov/projects/initiatives/pages/columbia-river-treaty.aspx

UCCRG (n.d.) Universities consortium on Columbia River Governance. URL: http://www.columbiarivergovernance.org/

UCUT (2005) In the field. http://www.ucut.org/in_the_field.ydev#news_paragraph6

UCUT (n.d.) Upper Columbia United Tribes. http://www.ucut.org/index.ydev

Vogel E (2012) Can an international treaty strengthen a region and further social and environmental inclusion? Lessons from the Columbia River Treaty. In: Cosens B (ed) The Columbia River Treaty revisited: transboundary river governance in the face of uncertainty. Oregon State University Press, Corvallis

Volkman JM, McConnaha WE (1993) Through a glass, darkly: Columbia River salmon, the Endangered Species Act, and adaptive management. Environ Law 23:1249–1272

Walker B, Salt D (2006) Resilience thinking: sustaining ecosystems and people in a changing world. Island Press, Washington D.C

Walker B, Holling CS, Carpenter SR, Kinzig A (2004) Resilience, adaptability and transformability in social–ecological systems. Ecol Soc 9(2):5 http://www.ecologyandsociety.org/vol9/iss2/art5/

Waples RS, Beechie T, Press GR (2009) Evolutionary history, habitat disturbance regimes, and anthropogenic changes: what do these mean for resilience of Pacific salmon populations? Ecology and Society 14(1): 3. [online] http://www.ecologyandsociety.org/vol14/iss1/art3/.

Weinman D (2014) Watershed Stewardship Groups in the Columbia Basin: final practicum report. University of Montana. Available from co-author Dr. Matthew McKinney.

Wheatley M, Frieze D (2009) Using emergence to take social innovations to scale. Kettering Rev 27:34–38

White R (1995) The organic machine: the remaking of the Columbia River. Hill and Wang, New York

Wolf A (2008) Healing the enlightenment rift: rationality, spirituality and shared waters. J Int Affairs 61(2):51–73