Building Transboundary Water Governance Capacity for Non-point Pollution: A Comparison of Australia and North America

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This paper uses the transboundary governance capacity framework (TGC) to compare responses to nonpoint pollution in the Great Lakes and transboundary water basins in North America and Australia. A step-wise approach to comparison refines our understanding of transboundary water governance institutions, their design and performance. Using case studies that move from similar to different geographic contexts, this comparative approach explores the opportunities and limits for mutual learning; it draws on a set of institutional indicators developed for the TGC framework to assess governance capacity within and across different geographic contexts. Governance capacity for nonpoint pollution has been uneven in the Great Lakes with pockets of success linked to high levels of multiple indicators. Capacity depends on legitimacy crafted through multi-layered participatory decision-making processes, buttressed by formal conflict resolution and the availability of regulatory mechanisms for third party enforcement if incentives and participation prove insufficient. In the Columbia, Colorado and Murray-Darling Basins 'issue linkages' have been used to remedy deficits in governance capacity by drawing from other water-related challenges, such as fisheries and water scarcity, where governance capacity exists. In all cases, transboundary governance capacity has required attention to 'process values' – that is the procedures used to come to decisions and implement nonpoint pollution programs. Future research should examine how attributes of transboundary governance capacity evolve in relation to environmental quality indicators; it should also identify finer grained measures of the indicators to ensure external validity and enable comparisons within and across case studies.

Keywords: adaptive governance, transboundary water governance, governance capacity, Great Lakes, Murray-Darling Basin, Columbia River, Colorado River, comparative water research, non point pollution

The 21st century will almost certainly be an era of increased global circulation of water issues, inquiry, expertise, and action . . . In light of the critical water problems faced in every region of the world, the next twenty years will require a major shift from largely implicit comparisons to rigorous comparative analyses.

(Wescoat, 2009)

They [architects of the River Murray Commission] looked to the newly formed United States-Canada Joint Commission to administer the St Lawrence and the Great Lakes and concluded that the Australian body should have powers, inter alia, to control river gauging, collect statistics, administer and control diversions under the agreement, control snagging operations, register river traffic, control joint works on the river and report on measures fully to utilize the waters.

(Clark, 1971) *(Referring to deliberations about transboundary water management in the Murray-Darling in the early 20th century based on the emerging lessons from the Great Lakes.)*

1.   Transboundary governance capacity: international lessons, comparative studies

The Great Lakes have long captured the interest of international observers (Newig & Fritsch, 2009). Great Lakes scholars and practitioners have also cast their sights abroad to learn from water policy innovations in Australia, the European Union (EU) and elsewhere (Heinmiller, 2006; MacDonagh-Dumler, 2009). Once a global leader in transboundary water governance, the Great Lakes' track record is now more mixed (VanNijnatten, 2016; Greitens, 2016; Gaden, 2016; Heinmiller, 2016). For example, Verweij (2000) asked why the Rhine is cleaner than the Great Lakes despite 'looser regulations' in the Rhine. He acknowledged the importance of voluntary stewardship in the Rhine, which contrasts with the strong role of the courts in the US portion of the Great Lakes. This comparison between the Rhine and the Great Lakes is just one example of the rapid growth in comparative water policy research over the past decade. This research has led to improved methodological and analytical tools used to diagnose the nature and sources of water governance challenges and to thereby identify the policy and institutional arrangements best suited for different contexts (Gondhalekar, Mollinga, & Saravanan, 2013; Srinivasan, Lambin, Gorelick, Thompson, & Rozelle, 2012; Wescoat, 2005, 2009).

We build on this growing tradition of comparative water studies to gain new insight about transboundary governance capacity in large, multi-jurisdictional rivers and lakes. We examine transboundary water quality management of four freshwater bodies in North America and Australia, chosen for their similar political economic circumstances and large size: the Great Lakes-St. Lawrence Basin (1.6 million km^2), Colorado River Basin (637,000 km^2), Columbia River Basin (673,000 km^2), and Murray-Darling River Basin (1.06 million km^2). These basins face the shared challenge of nonpoint water pollution. However, the dominant sources of nonpoint pollution vary from salinity issues in the irrigation-dominated Colorado and Murray-Darling to urban and agricultural runoff in the Columbia and Great Lakes.

The Great Lakes is in its own league, as the largest surface freshwater system in the world in volumetric terms. The abundance of water stands in sharp contrast to the relative

scarcity of water in semi-arid regions of Western North America and Southeast Australia. Nevertheless, Heinmiller (2006) notes a 'remarkable commonality' in the political systems of the Great Lakes region and Australia. In addition, all four basins are large, ranking in the top quartile of the world's major basins according to drainage area. The large size of these basins requires multi-level governance arrangements to combine local capacity with transboundary water institutions. These shared challenges and common features motivate efforts to learn from similarities and differences across these settings. In this paper, we aim to build on recent theoretical, historical and policy research about transboundary governance in North America and the Great Lakes by providing a comparative perspective (Flaherty, Pacheco-Vega, & Isaac-Renton, 2011; Macfarlane, 2014; Norman, Cohen, & Bakker, 2013)

This paper advances our understanding of the conditions that promote effective transboundary governance and enhance capacity to address complex water quality challenges. We employ the institutional indicators associated with the Transboundary Governance Capacity (TGC) framework to place the Great Lakes-St. Lawrence basin in a comparative perspective (VanNijnatten et al., 2016). In so doing, we test the external validity of this conceptual model elaborated for the Great Lakes to identify the opportunities for and limits of generalizable knowledge, as well as the insights and issues from individual cases. The next section frames the governance challenges associated with nonpoint pollution; it defines adaptive water governance in the context of large transboundary watercourses and highlights the gap between theory and practice. In the third section, we address this gap by comparing the evolution and performance of transboundary water quality institutions in the four basins, proceeding from similar (Great Lakes-Columbia) to different (Colorado and Murray-Darling) settings. The final section considers lessons learned in the Great Lakes and the other three basins, culminating with a set of emerging principles and implications for institutional and policy development.

The paper explores the following questions:

● What are the conditions that promote effective transboundary governance in large water basins?

● How can indicators of transboundary governance capacity be used to compare cases?

● What are the opportunities and limits of generalizable principles about the conditions promoting effective transboundary governance?

2. Nonpoint pollution: shared challenge for adaptive water governance

Governing large freshwater bodies is a 'wicked problem'; the nature of the problem is in dispute and subject to deep uncertainty about cause and effect (Batie, 2008; Patterson, Smith, & Bellamy, 2013; Rittel & Webber, 1973). There are no optimal solutions, and policies create consequences that are difficult to predict and often hard to reverse (Batie, 2008). Political borders rarely align with those of freshwater systems, a mismatch that adds complexity to water-human systems (Srinivasan et al., 2012). There have been growing calls to embrace this complexity (c.f. (Ostrom, Janssen, & Anderies, 2007)) and to

dissect the factors that contribute to adaptive water governance capacity in different types of rivers and lakes (Pahl-Wostl, Lebel, Knieper, & Nikitina, 2012).

Water pollution is broadly classed into point and nonpoint sources. Point sources can be identified, measured and regulated, while nonpoint pollution is diffuse and less tractable. Surface water runoff is the primary (human) source of nonpoint pollution from land use practices. Reducing nonpoint pollution involves a 'watershed' approach to account for land and water interactions. Rivers, lakes and aquifers differ in their level of urbanization, irrigation and in the land use patterns that drive nonpoint pollution. Nonpoint pollution is therefore a broad and diverse category of pollutants that range from herbicide, fertilizer, and salt from agricultural and residential land use to mine waste, toxic chemicals, and oil and grease from urban and industrial practices. Efforts to reduce nonpoint pollution depend on the precise land use mix and involve a potentially large, diverse group of stakeholders and private landowners (Hardy & Koontz, 2008).

Nonpoint pollution is a particularly challenging governance dilemma described by Yoder (2013) as a "collective-action puzzle". Transboundary watercourses have a finite capacity to absorb pollution, but it is often costly to curb or modify land use practices that contribute to the problem (Smith & Porter, 2010). The complexity of nonpoint pollution creates uncertainty and raises the costs of abatement. Finally, nonpoint pollution crosses multiple scales from the farm or household to the river or lake, requiring local action and landscape level coordination across political jurisdictions.

The complexity of nonpoint pollution has made it a prime focus for adaptive water governance. Adaptive water governance brings together two separate but complementary streams of thinking: adaptive co-management and water governance (Huitema, Mostert, Egas, Moellenkamp, Pahl-Wostl, & Yalcin, 2009). Adaptive management is based on experimentation coupled with the flexibility and mechanisms to shift course in response to learning from diverse forms of knowledge (Pahl-Wostl, 2007). This iterative learning characteristic of adaptive management, when coupled with the linkage dimension of collaborative management, results in adaptive co-management (Plummer & Armitage, 2007). Water governance, on the other hand, has become closely linked with inclusion of new actors and informal institutions, collaboration and bioregionalism, i.e., the alignment of political and natural boundaries (Huitema et al., 2009; Lee, 1994). Together, adaptive management and water governance promote "cross-level linkages, the conditions for partnerships that really share power, and ways to move from instrumental learning to learning about appropriate goals" (Huitema et al., 2009, p. 2).

Despite its intuitive appeal and potential benefits, adaptive water governance is notoriously difficult to pin down in practice. A number of recent studies attempt to operationalize the concept through indicators that can be measured at a range of scales in relation to various challenges, such as climate change and environmental quality. Pahl-Wostl et al. (2012) identify up to 29 measures associated with adaptive water governance distributed across several categories, including: 1) an encompassing legal regime, 2) legal recognition of the 'basin principle' for integrated water governance, 3) polycentric architecture balancing distribution of powers and coordination, 4) vertical and horizontal integration across levels of government, and 5) open access to and integration of diverse forms of knowledge.

The Transboundary Governance Capacity framework examined in this special issue introduces four institutional indicators – nature of enforcement, functional intensity, stability and resilience, and degree of legitimacy – as well as measures for them. Each indicator is designed to show, in a qualitative manner, the presence or state of the institutions and networks in relation to a specific basin and policy issue. The institutional indicators offer us the potential to operationalize adaptive water governance in a transboundary management setting based on a number of key challenges in water quality policy and management (see Figure 1 and Table 1).

The transboundary governance framework is compatible with multiple theoretical traditions and methodological approaches, following the distinction between frameworks, theories and models (Schlager & Blomquist, 1996). Frameworks establish the boundaries of inquiry and common conceptual vocabulary, while theories identify the relevant variables and causal relationships to explain social phenomena. The TGC framework is paired in this paper with the theoretical perspectives on "polycentric" governance[1] to understand the potential and constraints for integrated water governance in situations where authority is distributed across multiple formal and informal centres (Marshall, 2008; Marshall, Connell, & Taylor, 2013; Ostrom, Tiebout, & Warren, 1961). In the institutional design principles elaborated by Ostrom in 1990, the 'nesting principle' was used to describe the cross-scale governance challenges relevant for larger common pool resource systems
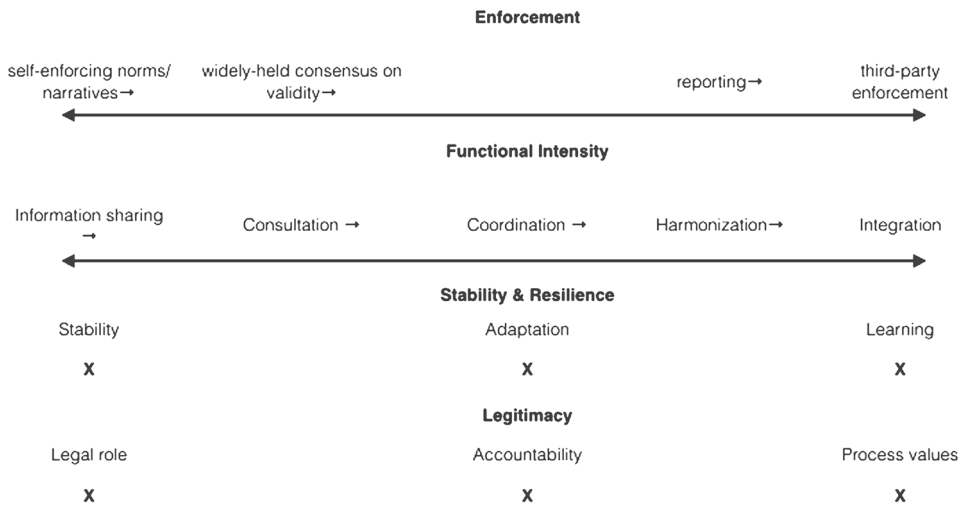

Figure 1. Transboundary Governance Capacity: Institutional Indicators and Attributes. *Enforcement and functional intensity form a gradient from informal to formal, while stability and legitimacy comprise multi-dimensional indicators for which multiple attributes are required and must be balanced.*

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[1] Polycentric governance arrangements involve 'many centers of decision-making which are formally independent of each other' but can function as a coherent system by taking one another into account in competitive, cooperative, and/or contractual relationships (Ostrom et al., 1961, p. 831). There is an extensive literature applying this to environmental and water governance, including the work by Marshall et al. (2013) on integrated water governance.

Table 1
Transboundary Governance Capacity Framework: Attributes, Indicators and
Key Challenges for Adaptive Governance

Attributes	Indicators (italicized) and Spectrum	Key Challenge/s for Adaptive Governance
Nature of Compliance	*Binding rules and practices (degree of constraint)* Combining self-enforcement (informal) and third party (formal)	Development and enforcement of basin and sub-basin water quality standards and management practices
Functional Intensity	*Intensity of Linkages* Information sharing, consultation, co-operation, harmonization, integration	Vertical and horizontal coordination mechanisms
Stability and Resilience	*Longevity, Learning and Adaptation* Evidence of stability, evidence of adaptation, evidence of learning	Conflict resolution Monitoring Responding to emerging issues
Degree of Legitimacy	*Accountability and Inclusion* Evidence of legal role, accountability mechanisms, and attention to process values	Fragmentation of accountabilities Public engagement and participation

(Ostrom, 1990) and operationalized by Marshall in terms of the twin concepts of subsidiarity (decisions taken at the lowest level possible) and complementarity (coordination institutions to deal with tradeoffs) (Marshall, 2008).

The paper also engages the concept of 'issue linkages' – borrowed from the literature on international regimes – to understand how transboundary governance capacity deficits in one area may be addressed by drawing from capacity for another area or issue for which capacity is relatively high or for which political coalitions are easier to form (Miller & Dolšak, 2007). The intersection of these two traditions – polycentric governance and issue linkages – provides fertile ground for examining how rivers and lakes build transboundary governance capacity across diverse historical, cultural and environmental contexts.

3.   Comparative methodology

There are a number of reasons behind the rapid growth in comparative water studies over the past 15 years. First, comparison informs policy decisions and governance by 'diagnosing' different types of water challenges and identifying the approaches best matched to different sets of circumstances (Cox, 2012; Ostrom & Cox, 2010). Diagnosis is needed to strengthen institutional fit in terms of matching the appropriate policies and institutions to the problems. A second reason for interest in comparative research is the potential to understand causal processes, and thereby better predict the pathways and trajectories of coupled human-water systems to better inform policy interventions (Molle & Wester, 2009; Srinivasan et al., 2012). A final reason is to build a theory of good water governance, a challenge Araral has described as water governance 2.0 (Araral & Wang, 2013). Teisman, Van Buuren, Edelenbos, and Warner (2013) frame this water

governance agenda in terms of 'increasing interdependency and need for joint action' in modern society.

There are two broad methodological approaches in comparative water studies. On the one hand, every case is unique. Context matters. The history, culture, and environment of a given setting are distinct and limit our ability to transfer knowledge across disparate settings (Ingram, 2008). At the other extreme, one-size-fits-all institutional blueprints are promoted as panaceas across a wide range of settings. This approach has been critiqued as a form of 'institutional monocropping' that can weaken resilience and robustness (Evans, 2004; Ostrom et al., 2007). A middle ground has formed between these two polar opposites based on case-oriented and configurational approaches to comparative research (Basurto & Ostrom, 2009; Rihoux & Marx, 2013).

The tensions between generalization and context-specificity are situated within broader developments in comparative social science methodology (Ragin, 2014) and policy transfer (Swainson & De Loe, 2011). These methodological developments underscore the importance of taking context seriously when considering the potential and limits of transferring lessons across different regions. They highlight the need to account for the political, cultural and institutional setting affecting the development and implementation of policies, as well as the causes of the problems in the regions being compared. For this reason, we chose to focus on four basins in democracies with advanced economies and mature institutions and multiple decades of experience with environmental and water policy development to address pollution across an increasingly complex and diffuse spectrum of pollutants. The potential pitfalls of generic comparisons should motivate increasing rigor and transparency, but not lead to a retreat from the endeavor (Wescoat, 2009).

3.1. Step-wise approach

We follow a step-wise process to explore the evolution and interaction of transboundary governance capacity indicators and water quality within and across a set of four basin-level case studies (Gondhalekar et al., 2013; Mollinga & Gondhalekar, 2014). Each case study has developed transboundary institutional arrangements governing nonpoint source pollution, albeit from difference sources. Transboundary refers to governance arrangements spanning national and/or sub-national political borders. The step-wise approach adopts multiple inferential approaches to elaborate and refine the conceptual model for transboundary governance capacity studied in this volume within and then across cases. The comparative logic is to shift progressively from the most similar to the most different systems. It first uses the most similar system design to test internal validity by exploring variance within similar cases (Mill's method of difference) and then similarities across similar cases (Mill's method of agreement). It then examines external validity by expanding the analysis to different types of cases using the most different system design and the same sequence of Mill's method of difference and then method of agreement.

This approach generates insights about the conceptual model and empirical experiences in a single case before examining a case with similar conditions to test the validity

of that model. Finally, the comparison expands to include a set of cases that vary in terms of one key contextual factor (in this instance from temperate to semi-arid conditions). This final step distinguishes the crosscutting (all four cases) versus context-specific dynamics in different types of cases. Thus, the forthcoming analysis involves four steps proceeding from the introduction and application of the conceptual model for transboundary governance capacity in the Great Lakes context (step 1, following Van Nijnatten et al., 2016). This is followed by the application of the conceptual model to learn from cases with similar circumstances (step 2) and different conditions (step 3). The final step (4) of the comparison is used to derive lessons about the factors enhancing or reducing transboundary governance capacity in water quality governance.

Step 1. Great Lakes: A primary reference case to elaborate a conceptual model of transboundary governance capacity.

The rest of the special issue has mapped the conceptual model and causal properties of transboundary governance capacity based on institutions and networks. This framework introduces four indicators of institutions – nature of compliance, functional intensity, stability and resilience, and degree of legitimacy (VanNijnatten et al., 2016). The other papers test and elaborate the conceptual model of transboundary governance capacity based on lessons from water allocation, nearshore water management, invasive species and fisheries – within the Great Lakes basin. This is used to validate the conceptual model, which is applied here to nonpoint source pollution using the indicators from Figure 1 *across* four basins.

Step 2. Columbia River: Temperate basin with spatial and temporal variability. Learning from similarities, using a secondary case.

The Columbia River basin is broadly similar to the Great Lakes basin in terms of political, institutional and physical characteristics (despite important differences between lake versus river systems and hydro-climatic regimes), and is therefore a suitable testing ground for the TGC conceptual model in a setting where the model is expected to apply, despite important spatial and temporal variability in streamflow, which is discussed below.

Step 3. Colorado and Murray-Darling: Learning from differences.

The conceptual model is applied to a third set of cases that are fundamentally different in one key respect and that therefore represent a distinct category of case. The Colorado and Murray-Darling basin share political and institutional features (belonging to federal countries and developed economies) but differ in physical terms; they are defined by their semi-arid location and are dominated by irrigation and the associated salinity issues and water quality challenges. The contrast between the Great Lakes and the water-stressed regions of the Colorado and Murray-Darling highlights the impact of physical characteristics on transboundary governance capacity.

Step 4. Lessons Learned.

The comparison identifies a mixture of general principles and context-specific attributes associated with transboundary governance capacity. General "principles" refer to the governance design and trends common to all cases – both similar and different. They can be considered necessary, or essential, conditions of transboundary governance capacity. Context-sensitive attributes, on the other hand, are based on the attributes and dynamics relevant only to specific cases or issues, e.g. water abundant versus water scarce, urban versus rural and a range of political economic, geographic and historical conditions. They can be considered sufficient conditions, but not necessary across all settings.

The next sub-section introduces the four cases, their nonpoint pollution and transboundary water quality governance arrangements in the context of the conceptual model, and the indicators of transboundary governance capacity developed by VanNijnatten et al., (2016). We compile and analyze primary documents to characterize the qualitative indicators for the transboundary nonpoint source pollution institutions.

4.   Case Definition and Institutional Overview

Step 1: Great Lakes

The Laurentian Great Lakes is the world's largest surface freshwater system comprising of five hydrologically connected lakes; Lake Superior, Lake Michigan, Lake Huron, Lake Erie and Lake Ontario. Together these lakes span 1200 km from west to east and contain 2300 km^3 of water, providing 84% of North America's surface freshwater and 21% of the world's supply of surface freshwater (Fuller, Shear, & Witting, 1995). Despite this large volume, renewal of the waters represents less than 1% of the total volume of water per year. The large surface area and long retention time makes them susceptible to a range of pollutants from agricultural runoff containing fertilizers, leachate from waste disposal, industrial runoff, waste from cities, and direct atmospheric pollution from rain, snow and dust. The Great Lakes basin spans the US and Canada and is home to over 33 million North Americans in Ontario, Québec, Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York (Fuller et al., 1995). It is also home to a large indigenous population represented by 120 Native American/First Nation Authorities (Crane, 2012). The lakes provide habitat to over 350 species of fish and 3500 species of plants and animals and four types of wetlands (Fuller et al., 1995). This basin has considerable social and economic significance, providing drinking water and recreation and an economic output of US4.7 trillion dollars, contributing 28% of North American economic activity (BMO, 2015)

Nonpoint sources of pollutant inputs are particularly challenging for the region, as proven technologies and regular instruments are not well defined. The Great Lakes receive water and accompanying nutrients from many tributaries and draining areas, ranging from pristine forests to intensively farmed areas to large urban centers; nutrient input from these tributaries is extremely variable (Robertson & Saad, 2011). Land use

and land cover changes associated with urbanization have affected the Great Lakes, with responses being particularly pronounced in the near shore zone. The bulk of the change consisted of forested and agricultural lands converting to high or low intensity development, roads, or early succession vegetation. More than half of these changes are considered to be irreversible, which could result in negative consequences such as biodiversity loss, exacerbated by climate change and point source inputs (King et al., 2013). In particular, nutrient loading has caused eutrophication in small and large embayments around the Great Lakes (e.g., Green Bay in Lake Michigan) to wide-scale eutrophication in Lake Erie. In 2011, Lake Erie experienced the largest harmful algal bloom in its recorded history, with a peak intensity over three times greater than any previously observed bloom. Long-term trends in agricultural practices are consistent with increasing phosphorus loading to the western basin of the lake, and that these trends, coupled with meteorological conditions in spring 2011, produced record-breaking nutrient loads. Significantly reducing nonpoint source loads is difficult because: "not only are the sources spatially distributed, but the methods used are primarily voluntary and incentive based and thus difficult to target and track (Scavia et al., 2014)." Reducing nonpoint source loads is complicated by the fact that the response time between an active intervention and an ecosystem response can be years or longer, and the results can only be measured cumulatively in space and through time.

Compliance mechanisms for Great Lakes management tend to be binding for nonpoint pollution in the Great Lakes states. On the U.S. side, the Great Lakes Initiative requires that states develop and implement Total Maximum Daily Loads (TMDLs), which identify the maximum amount of a pollutant for a receiving body under section 303(d) of the Clean Water Act for specific rivers and tributaries. No such mechanism exists in Canada, although under Ontario's Clean Water Act, Source Water Protection Plans result in cooperation and coordination of watershed management initiatives within and across municipal boundaries in partnership with a broad range of stakeholders. On the matter of functional intensity, transboundary Lakewide Management Planning teams can be considered harmonized, since loading requirements necessary to restore ecosystem resilience are shared by all practitioners for a given Lake. Coordination has been in place since the creation of Lakewide Management Plans in the late 1980s under the Great Lakes Water Quality Agreement 1987 amendment. By reporting progress to the public, the International Joint Commission enables public engagement and adds process legitimacy to the efforts. Public engagement has also contributed to stability and legitimacy tied to local capacity. However, local capacity is uneven, and hence so are stability and legitimacy, as explored in the discussion section below. And while joint monitoring of each lake is coordinated binationally, there is no clear evidence of adaptation, of learning by doing and reforming practices, or of institutional arrangements based on new knowledge. This is perhaps reaching a point of change with the increased emphasis on deepening the understanding of why Lake Erie's algal problems are creating turmoil. Experimental interventions to test so-called "best practices" could generate improved understanding for program and policy adaptation.

Step 2: Columbia Basin

The Columbia Basin is one of the most developed rivers in Western North America with over 200 dams supporting an average of three million acres of irrigation and 16,000 megawatts of hydropower. Like the Great Lakes, the Columbia straddles the US and Canada border. The basin drains almost 700,000 km^2 across seven US states, one Canadian province and a number of First Nations and Tribal Reservations. The Snake, Deschutes, Clearwater, Salmon and Willamette Rivers form important tributaries to the mainstem, while the John Day remains the longest free-flowing river. An average annual runoff of 1.71 billion m^3 makes the Columbia the fourth largest river in North America by volume (National Research Council, 2004). Unlike the Great Lakes-St. Lawrence, however, the basin experiences substantial spatial and temporal variability in runoff due to a snowmelt-dominated hydrograph. Predevelopment runoff patterns include 75% of annual runoff during the late spring and summer and only 25% during the fall and winter. The ratio of seasonal peak to average runoff conditions is markedly higher in the Columbia than the St. Lawrence (Hamlet, 2003). The seasonal variability has led to efforts to develop the river through a system of hydropower dams – the Federal Columbia River Power System – which has transformed the river's hydrology (flattening out seasonal variability), geomorphology and ecology.

Salmon are an iconic feature of the Columbia's eco-hydrology, culture and economy. Nonpoint pollution has been addressed in the context of wider watershed planning and salmon recovery efforts to address the impacts of agricultural and residential land use. Nonpoint pollutants include suspended solids, sediment, nutrients, metals and toxins. In other words, there is a diverse range of pollutants associated with agriculture, forestry, mining and residential land uses.

Water management institutions have been described as a "patchwork quilt" given the number of federal, international, tribal, state and local entities involved (Schloesser, Smithee, Longton, & Kovalak, 1997). The Columbia Basin Treaty coordinated flood control and hydropower between the US and Canada but omits wider management concerns associated with quantity, quality and environmental needs. Within the US, the Northwest Power Act of 1980 is the legislative basis for interstate coordination on power and conservation matters, which have led to the development of sub-basin plans that touch indirectly on water quantity and quality issues. The 1972 Clean Water Act and its amendments address point source pollution through its National Pollutant Discharge Elimination System and nonpoint pollution through the development of Total Maximum Daily Loads (TMDLs). State regulatory agencies typically adopt the TMDLs and submit them for approval by the federal Environmental Protection Agency. To date, 51 TMDLs have been approved spanning the main stem of the Columbia and 14 of its tributaries (Environmental Protection Agency, 2014).

The compliance mechanisms for transboundary institutions in this case tend to be binding for nonpoint pollution (in the US), as states are required to list impaired waters and set TMDLs for them. Yet nonpoint pollution also depends on self-enforcing norms among private landowners, often facilitated by the efforts of nonprofit organizations, such as the Columbia Basin Trust in Canada and a number of watershed conservancies and trusts in

the US. An approach comparable to that of TMDLs is lacking on the Canadian side of the basin, although nonpoint pollution is addressed through regulations and codes across many land use planning and management bodies (e.g. forestry). In terms of functional intensity, transboundary institutions for nonpoint pollution management in the US are "harmonized" because TMDL programs are typically developed by states and approved by the federal government. Issue linkages between nonpoint pollution and salmon recovery strengthen the coordination and harmonization of water quality governance across the four main states on the US side: Oregon, Washington, Idaho and Montana. However, coordination remains limited across the US-Canada border. On the other hand, the stability and resilience of transboundary water quality governance for nonpoint pollution can be considered high due to the relatively long period of learning under the Clean Water Act and the capacity to draw on the vast financial and monitoring resources dedicated to salmon recovery. The dependence on state governments and watershed organizations for planning and implementation of TMDLs has bolstered legitimacy through strong stakeholder involvement, thereby increasing process values, although often at the cost of slowing development and implementation of TMDLs. Legitimacy is far from uniform within and across the states in the US portion of the Columbia Basin.

Step 3: Colorado and Murray-Darling

The Colorado and Murray-Darling Rivers are large semi-arid rivers with a long history of irrigation development and large dams. Unlike the Great Lakes, the Colorado and Murray-Darling experience water scarcity and sustained, multi-year droughts. The Colorado and Murray-Darling are considered "closed rivers" due to the reductions in outflows to the sea to 0% and 40% of long-term average predevelopment outflows respectively (Grafton et al., 2012). The combination of water scarcity, climate variability and irrigation development has produced salinity challenges as a primary source of nonpoint pollution. Both rivers are shared across multiple jurisdictions in federal political systems, lending a strong analytical basis for comparison of transboundary water quality management between the Great Lakes on the one hand and the water-stressed Colorado and Murray-Darling on the other, despite divergent physical characteristics and associated differences in land use and nonpoint pollution.

The Colorado River includes seven states in the US and two in Mexico and has supported extensive irrigation development, hydropower production, and rapid urban growth in the Western US (U. S. Bureau of Reclamation, 2012). Long-term average annual flows are approximately 18.5 billion m^3 with high inter-annual variability. Reservoir storage buffers climate variability and sustained drought conditions, which have occurred regularly in the observed and paleoclimate records (Woodhouse, Gray, & Meko, 2006). Upstream development and diversions have caused declines in the health of the Delta ecosystem (Garrick et al., 2013).

Salinity is a primary source of nonpoint pollution in the Colorado and causes an estimated $295 million USD in annual damages at 2010 concentrations (U. S. Bureau of

Reclamation, 2013). Nevertheless its transboundary management capacity is considered to be high due to strong compliance with salinity targets set under the 1974 Basin Salinity Control Act (hereafter "the Act"). In the early 1970s, farmers in Mexico complained due to the poor water quality of deliveries from the US under the 1944 International Treaty governing water sharing in the Colorado. This followed earlier concerns in the mid-1960s, which led to the Colorado Basin Salinity Control Program and the 1965 Colorado River Water Quality Act. A "minute", or amendment, to the international treaty (minute 242) in 1973 committed the US to deliver water no more than 115 parts per million, or ppm (+/− 30ppm), over the annual average salinity at Imperial Dam in the US. This set in motion a series of actions to control salinity levels under the 1974 Act.

The Basin Salinity Control Program processes 1.3 million tons of salt per year (U. S. Bureau of Reclamation, 2013). The compliance mechanisms draw from binding authority under the 1974 Act, including the potential for third party enforcement by the federal government. Recourse to third party enforcement has not been necessary due to emerging norms and incentives for states and irrigation districts to participate in salinity control projects. The Basin Control Act and its implementation by the US Bureau of Reclamation is vertically integrated from the irrigation district to the basin level with high functional intensity to coordinate horizontally across states and within states. The federal government identifies salinity control projects with input from a Colorado Basin Salinity Control Forum, its member states and stakeholders. This decision-making and joint monitoring program builds process legitimacy and enhances longevity, adaptation and resilience. These arrangements have ensured salinity targets have been met continuously despite unprecedented drought conditions since 1999 and chronic overallocation in the Basin.

The Murray-Darling Basin (MDB) lies within the jurisdictions of four states, a territory, and the Commonwealth government and totals over a million square kilometers. It is the country's most productive agricultural region, generating approximately two-thirds of irrigated agriculture. Average annual outflows to the sea at the Murray mouth have declined from 12.23 billion m^3 per year (prior to water resource development) to 4.73 billion m^3 per year (after upstream development) (Commonwealth Scientific and Industrial Research Organization, 2008). Like the Colorado, droughts and climate variability have prompted irrigated agriculture and reservoir storage development. Upstream diversions and dams in the MDB have led to declines in ecosystem health including flood plain degradation, salinity issues, thermal pollution, invasive species, and loss of biodiversity (Connell & Grafton, 2011; Pittock & Connell, 2010).

Nonpoint pollution has been closely connected with water scarcity and extractions. The 1991-2 algae blooms on the Darling River garnered international attention to the problem of sustainability in the stressed and variable river system. The 2001 Basin Salinity Management Strategy (BSMS) builds on prior efforts at integrated management of salinity under the 1988 Salinity and Drainage Strategy. The Basin Salinity Management Strategy established a target of 800 electrical conductivity units for salinity 95% of the time at the compliance point in Morgan South Australia. At the time of the Strategy's adoption salinity impacts were almost $300 million AUD per year due to the combined effects of dryland salinity and

salt associated with consumptive users. The Basin Salinity Management Strategy adopted in 2001 created a 15-year strategy based on two innovative features: end-of-valley targets and salt interception schemes (Murray-Darling Basin Commission, 2001).

The Strategy addresses four objectives, including maintaining water quality, controlling salt loads, controlling land degradation and maximizing the net benefits of salt reduction schemes. This Strategy is focused on nine elements and principles, highlighted by multi-level capacity building to implement the strategy, identify values and assets at risk, set targets and manage tradeoffs guided by salinity and catchment management plans. Monitoring, evaluation and reporting are used to ensure accountability, stability and process legitimacy.

Transboundary governance capacity is high as the BSMS has recently been incorporated into a binding Basin Plan adopted into national legislation in 2012 with potential for third party enforcement. The success of the strategy has been based on the clear division and assignment of responsibilities. The federal agency is tasked with setting targets, and the states are responsible for achieving them through collaboration with irrigation districts, informal institutions and the use of incentives to coordinate water users. Information and reporting is required from states and the federal authority governing the Basin – the Murray-Darling Basin Authority. These governance arrangements contribute to an integrated approach in terms of functional intensity. The extensive reporting requirements enhance legitimacy and accountability using independent audits, salinity registers and monitoring tools. This transparency in turn feeds stability and resilience despite sustained droughts, intense flooding and complex, landscape level environmental water recovery efforts affecting land-water interactions. Political backlash associated with centralization and formal institutions presents a threat to resilience, as evidenced by efforts to adopt a comprehensive Basin Plan from 2010-2012 without early and effective stakeholder engagement. The efforts to forge issue linkages in the Murray-Darling are explored in the discussion section to expose the potential tradeoffs and trajectories across transboundary governance capacity.

5.   Discussion: Comparison, Implications and Principles

The indicators of transboundary governance capacity offer a qualitative basis for comparison. Their validity and utility can be considered along two dimensions: internal and external validity. The other papers in this special issue test the internal validity of the measures by assessing the capacity to address specific policy challenges within the Great Lakes basin. External validity considers the comparability within and across cases needed to enrich theory and develop policy lessons.

Step 4: External Validity, Theory Development and Policy Implications

The test of external validity involves benchmarking the Great Lakes against other regions with shared challenges using a consistent and comparable set of indicators. Figure 2
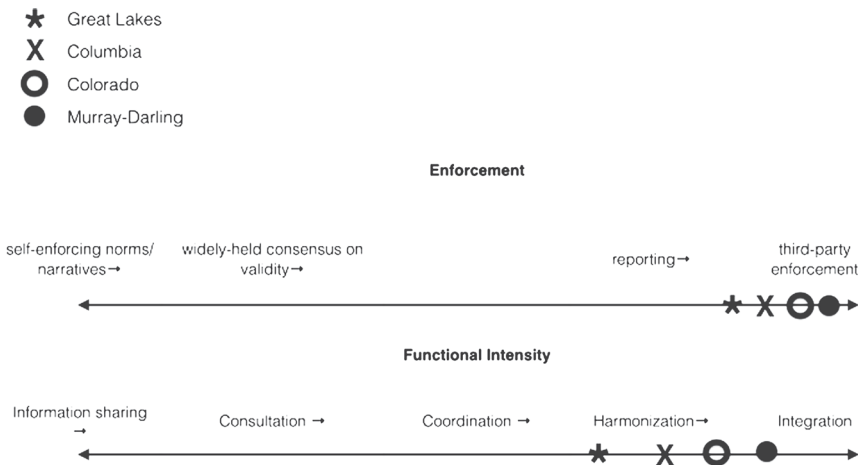
Figure 2. Comparative perspective on Transboundary Governance Capacity: Institutions for nonpoint pollution. *More formal enforcement mechanisms or more intense linkages do not preclude the prior or concurrent use of informal enforcement mechanisms or less intense linkages. Indeed, the availability of these less formal mechanisms and less intense linkages is often critical to engender trust and norms of reciprocity, while the availability of more formal mechanisms and intense linkages can be triggered should the others fail. Positioning of the cases is meant to be indicative and illustrative, and future research should systematize measurement for benchmarking and comparison.*

considers the first two indicators – compliance and functional intensity-using the qualitative measures and descriptive analysis presented above. From this qualitative comparison, we can surmise some useful cross-case trends. First, third party enforcement is high across the board. Even in the Great Lakes, where nonpoint pollution regulation is not (yet) binding in terms of the Water Quality Agreement, the Great Lakes Initiative in the US establishes a mandate for setting TMDLs for impaired waterways. This is identical in the US portion of the Columbia Basin, leaving a potential compliance "gap" in the Canadian portion of both basins. The degree of compliance constraint is slightly higher in the Colorado and Murray-Darling for reasons explored below, but the basins are closely clustered in terms of compliance.

There are moderate differences between the basins in terms of functional intensity. Vertical integration in the Colorado and Murray-Darling basins addresses narrowly defined salinity control issues. The Columbia and Great Lakes are limited to harmonization through nonbinding coordination mechanisms like the Fish and Wildlife program of the Northwest Power and Conservation Council (Columbia), and the Great Lakes Initiative and Lakewide Management Plans (Great Lakes).

The legitimacy of the transboundary governance institutions for nonpoint pollution varies the most across the basins of the four indicators due to a combination of reasons, principally linked to the process values. Process values and public engagement are integral to the fish and wildlife recovery and associated watershed planning efforts in the Columbia, which have provided the primary venue for developing and implementing TMDLs associated with the pollutants that impair salmon habitat. This is an example of "issue linkage" enhancing capacity in one policy domain (nonpoint pollution) by connecting it

successfully with another policy issue (salmon, watershed planning) where public engagement processes have enhanced legitimacy. However, issue linkages can cut both ways in terms of process values; in the Murray-Darling, issue linkages connected salinity to broader and highly contested water allocation concerns. Efforts to establish a comprehensive basin plan that integrated salinity management – where process values and legitimacy had been considered high – with water allocation issues – where consultations triggered backlash – appear to have undermined, or at least slowed, progress (Crase, O'Keefe, & Dollery, 2013). Therefore, the long-term prospects and trajectory of transboundary governance capacity are at risk in the Murray-Darling.

The comparative analysis in this paper also highlights the importance of understanding: the nature and boundaries of the policy problem; interactions, synergies and tradeoffs among transboundary governance capacity attributes; and policy lessons that could be transferred and adapted across different settings with careful attention to context and path dependency issues.

5.1.   *The nature of the problem: not all nonpoint pollution is created equal*

Comparative research requires careful delineation of the policy problem to enhance transboundary capacity matched to local and contextual circumstances. The contrast between the Great Lakes and Columbia, on the one hand, and the Colorado and Murray-Darling, on the other hand, hinges upon one key contextual factor: hydroclimatology. The main distinction, however, lies in the associated differences in land use and NPS pollutants in these two settings. The Great Lakes and Columbia face a heterogeneous mix of nonpoint pollutants generated from diverse land use practices (see Table 2). For example, the Clark Fork tributary of the Columbia has TMDLs for seven pollutants ranging from metals to nutrients. By contrast, the Colorado and Murray-Darling are irrigation-dominated regions whose land use patterns are associated principally with salinity issues, even though other sources of agricultural and urban drainage are not trivial. In short, NPS pollution issues are not created equal; conversely, there appears to be an inverse correlation between the heterogeneity of land uses and the capacity of transboundary institutions. Single-issue NPS pollution is amenable to vertically integrated transboundary governance arrangements akin to the Basin Salinity Management Strategy in the Murray-Darling and the Salinity Forum in the Colorado. Multi-faceted issues in the Great Lakes and Columbia present more "wicked" problems for governance, which illuminates the second major implication of the study.

Table 2
Relationship between Scope, Enforcement Capacity and Issue Linkages

Scope/Enforcement	Lower Capacity	Higher Capacity
Narrower	Toxins	Salinity (Colorado and Murray-Darling)
Broader	Multiple NPS pollutants (Great Lakes)	Multiple NPS pollutants with issue linkages (Columbia)

5.2. The importance of issue linkages to achieve integrated governance responses for complex problems

In the Columbia, the complex, diverse and diffuse sources of NPS pollution pose challenges to horizontal and vertical coordination, particularly due to the importance of private landowners and extractive industries (mining) whose behaviors contributes to the problems. While water quality regulation under the Clean Water Act has functioned well, salmon recovery under the Endangered Species Act has been a primary catalyst in the Columbia. This shows the power of issue linkages to generate transboundary governance capacity by connecting issues where capacity exists to issues where it is more limited. In the Columbia, the Bonneville Power Authority's Fish and Wildlife program has funneled millions of dollars to salmon recovery since the turn of the century in coordination with the Northwest Power and Conservation Council. This effort has coincided with more bottom-up initiatives by states and resource users, who have been integral to the development and implementation of TMDLs at the watershed level. The Great Lakes face similarly complex and diverse NPS challenges, and equally have the potential to draw from capacity in key areas to address nearshore water quality challenges. Examples lie in Great Lakes Fisheries, and the widespread public interest in safeguarding the Lakes as "swimmable, drinkable, and fishable". Another prime example lies in the Great Lakes binational management under the Great Lakes Water Quality Agreement (1972, updated most recently in 2012) with its longstanding goal of restoring the chemical, physical and biological integrity of the waters of the Great Lakes. The lessons from that process are considered briefly below.

5.3. Beware of crowding out local and less formal Transboundary Governance Capacity

The centralization and integration of river basin governance in the Murray-Darling demonstrates the risk of taking issue linkage and formalization too far, however. The 2007 Commonwealth Water Act (Australia) stipulated comprehensive planning efforts to integrate salinity with a far-reaching effort to "optimize the social, economic and environmental uses" of the water in the Basin. The scope was comprehensive and exhibited high institutional capacity across all indicators considered here. Functional intensity achieved integration arguably at the expense of legitimacy, which threatened to unravel the hard fought consensus and cooperation on salinity management (Crase et al., 2013).

5.4. Context-specific insights in the Great Lakes

The general implications outlined above can be interpreted within the context of the Great Lakes. The need to maintain and foster less "intense" and less formal forms of functional integration was illustrated in the Columbia Basin (where this has happened) and the Murray-Darling (where it has not happened). This is particularly relevant and resonant in the Great Lakes in its efforts to address nearshore water quality governance issues. The Great Lakes Water Quality Agreement has led to efforts to maintain beneficial uses and to restore the health of "areas of concern". In the context of nonpoint pollution, this agreement has

resulted in collaborative efforts that are non-binding, but in many instance, these prove to be very successful in the regeneration of ecological resilience. With so many jurisdictions and stakeholders, and the range of threats to the socio-economic and environmental integrity of the region, the question of who governs the Great Lakes and how these governing arrangements are coordinated are pertinent to the discussion of functional intensity. Command and control governance is no longer viable; rather a more distributed system is needed. One of the challenges is deciding: whom to engage, in what proportions, at what time, and at what level. The experience-based knowledge of stakeholders who are transparently involved gains saliency, legitimacy and credibility (Krantzberg, 2009).

The US and Canada need to reexamine modes of public representation in decision-making, but experiments and lessons are emerging at the local level. One important example is Collingwood Harbour Remedial Action Plan on the shores of Georgian Bay, which falls within the jurisdiction of one municipality. The Collingwood Harbour RAP was exceedingly effective in resolving the consequences of historic misuse (Krantzberg & Houghton, 1996). This is in part a function of the inclusiveness of stakeholder representation and goal setting. Inclusivity lends legitimacy, stimulates accountability, and can galvanize potentially adversarial stakeholders. Sproule-Jones (2002) has observed that the wider the scope of stakeholder representation, the stronger the performance of the RAP. While all orders of government need to participate to make this agenda a reality, real movement towards sustainable cities can be cultured through the civic consciousness generated on a local level. Krantzberg (2006) discusses how civic consciousness encouraged individuals involved in the Collingwood Harbour RAP to act cooperatively. This provided the context for cooperative action according to ethics, despite economic and other motivations which could encourage actions that were otherwise (Moore, 1994). The honest inclusion of a community's representatives as partners in decision-making, made for successful community participation in the governance ethic of the Collingwood Harbour RAP (Krantzberg, 2003). Such experiences provide principles for maintaining the "less intense" forms of functional integration needed to foster legitimacy, stability and learning. The governance framework evolved from RAP development through to implementation, responding to new information, monitoring and progress, and modification of stakeholder engagement processes, responsibilities, accountability and authority. Less successful locations can be characterized by linear, top-down management, with little attention to deep engagement, co-management principles, and evolution of the decision making process. Such traditional, static processes represent a significant governance deficit. Understanding the mechanisms that allow program decision-makers to utilize adaptive management techniques to continuously modify programs based on new results, could accelerate cleanup efforts in other geographic regions of the Great Lakes and internationally (Hall, O'connor, & Ranieri, 2006)

Conclusions

The Great Lakes basin is one of a kind, and yet its nonpoint pollution issues are not unique to the region. The shared challenge of NPS pollution creates potential for mutual learning with other large and complex transboundary rivers, lakes and aquifers.

The comparison of the Great Lakes with the Columbia, Colorado, and Murray-Darling generated lessons about transboundary governance capacity, using indicators and step-wise insights to benchmark the basins, test the external validity of the indicators and explore several insights, principles and implications for theory and practice. The cases in the Great Lakes and Columbia show the potential to learn from similar circumstances, where the Columbia's transboundary institutional and network capacity has derived from successful issue linkages. Equally, there is potential to learn from the successes and failures experienced in different settings; the narrower scope of NPS pollution challenges in semi-arid, irrigation-dominated regions has given way to higher compliance capacity but mixed success in terms of maintaining the less intense and less formal forms of functional integration needed to enhance legitimacy. Achieving more formal attributes of transboundary governance capacity should not crowd out informal attributes and local capacity, and should complement less formal and intense networks and institutions.

This analysis represents an attempt to place the Great Lakes in a comparative perspective and contribute to the wider agenda of comparative water studies in three main areas. First, there is a greater need for systematic diagnosis of water management challenges to understand the policy and institutional approaches appropriate for different challenges and contexts. Second, there is growing potential to use comparative studies to generate insights and policy recommendations based on the lessons learned from both similar and different cases. Finally, comparative studies can draw from and contribute to emerging frameworks and theories for understanding complex social-ecological systems and the governance mechanisms that enhance or reduce adaptive capacity and resilience in such settings. The field of water governance has embarked on a long-term agenda for comparative studies, and this analysis demonstrates that the Great Lakes is an ideal laboratory to advance our understanding and application of good water governance in transboundary settings. Future research should examine the configurational and longitudinal relationship between transboundary governance capacity indicators and environmental quality as methods for comparative water studies mature.

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