Assessing transboundary scientific collaboration in the Great Lakes of North America

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ABSTRACT

Sustainably managing the Great Lakes of North America (including ecosystem health, fisheries, tourism, and water quality) in a transboundary regulatory setting represents a significant and enduring challenge for society. Recognizing the role that scientific institutions can play in framing problems, informing responses, stimulating public debate, and monitoring the effectiveness of policy actions in diverse contexts, we assess the properties of the Great Lakes knowledge production apparatus. Using bibliometric analyses, the frequency and intensity of Great Lakes-related scientific knowledge collaboration are analyzed over the 15-year period from 2000 to 2014, focusing on organizational, institutional, and geographic characteristics. The results reveal generally robust scientific collaboration between government and academic institutions but also a remarkable USA–Canada cross-border disjuncture, the latter being a surprising trend given the transboundary nature of the social–ecological issues being faced. Our findings inform ongoing efforts to enhance transboundary governance capacity in the Great Lakes region.

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Introduction

In the context of the Great Lakes Governance System (Krantzberg and Manno, 2010), the task of sustainably managing complex social–ecological systems (including ecosystem health, sustainable fisheries, tourism, and water quality) in a transboundary regulatory setting represents a significant and enduring challenge for governments (McLaughlin and Krantzberg, 2011). The Great Lakes contain nearly 21% of the world's fresh surface water (U.S. Environmental Protection Agency, 2012) and are home to 95 million people, generating a gross regional product of over $4 trillion USD in 2009 (NOAA Coastal Services Center, 2012). They also serve as an international boundary between Canada and the USA, bordering Ontario, eight states, a dozen metropolitan areas, and 75 First Nation communities in Canada alone, resulting in substantial policy overlap and regulatory diversity (Assembly of First Nations, n.d.; U.S. EPA, 2013). Significantly, the Great Lakes are known to be under immense stress, with overfishing, toxic chemicals and contaminated sediment, nutrient loading, invasive non-native species, and hydrologic alterations undermining the resilience of the social–ecological system (McLaughlin and Krantzberg, 2012).

Recognizing the complexity of these challenges, government and industry on both sides of the border have long invested heavily in scientific research in order to help clarify the different issues at stake and inform appropriate policy and management responses.

However, for scientific research to meaningfully support complex system innovation, the resulting knowledge needs to be carefully transferred and integrated across a number of geographic, cultural, and institutional boundaries (Klenk et al., 2010a) based on processes that are responsive to changing problems and tasks (Wellstead and Stedman, 2007). This presents a significant issue for science and policy, raising important questions concerning how best to approach the diverse transboundary challenges facing the Great Lakes region (Henquinet and Dobson, 2006; Krantzberg and Manno, 2010), with recent calls for enhancements in "transboundary governance capacity" (see Great Lakes Policy Research Network, 2015), and a "shift in the mindscape of the Great Lakes regime" toward institutional arrangements that encourage greater co-learning and collaboration across boundaries (McLaughlin and Krantzberg, 2011, p. 391). While there have been successful basin-wide efforts by the scientific and policy community in the past, most notably the curtailment of the sea lamprey invasion beginning in the 1940s and coinciding with the formation of the Great Lakes Fishery Commission (see Gaden et al., 2013), the contemporary status of transboundary scientific collaboration has received little systematic examination. Important questions in the context of understanding innovation in the region's transboundary governance systems include which organizations comprise the scientific knowledge production apparatus that supports Great Lakes governance and to what extent are they collaborating across organizational, institutional, and jurisdictional boundaries? In response to these questions, this paper seeks to offer an initial assessment and visualization of the Great Lakes

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scientific research network using bibliometric data, with a view to informing ongoing research and policy discussions toward fostering innovation in the Great Lakes governance system.

Data sources and methods

Co-authorship of published papers (i.e., multi-authored publications) was used as a proxy measure of scientific collaboration. Although co-authored papers are only a partial indicator of collaborative activity, a bibliometric analysis of co-authorship data offers a practical, cost-effective, verifiable, and unobtrusive method of approximating collaborations in scientific research (Glänzel and Schubert, 2005; Kats and Martin, 1997; Klenk et al., 2010a, 2010b; Melin and Persson, 1996). The methods used in this study followed the established contours of assumptions, procedures, and caveats involved in relying on the co-authorship of papers (see Melin and Persson, 1996).

Data were derived from Elsevier's Scopus database accessed online on February 11, 2015. Scopus is the largest abstract and citation database of peer-reviewed literature, indexing over 20,000 journals worldwide and considered to be one of the most comprehensive and reliable sources of scientific information across all research fields (Gorraiz and Schloegl, 2008). The search criteria comprised two components. The "thematic" criteria focused on Great Lakes science as it relates to the holistic and interconnected view of the system (e.g., search terms such as "ecosystem," "basin," "watershed/way," "climate," "policy," and "governance"). This was combined with the "geographic" criteria (e.g., "Great Lakes," "North America," "Ontario," and "Detroit") to search for papers that satisfied both criteria in either the title or in the abstract (see Fig. 1 for complete search terms). The search focused on a 15-year period from 2000 to 2014 and comprised journal articles including notes, letters, reviews, and editorials. From 4087 papers that met the selection criteria, a final set of 3959 published papers were retained after manual quality control in which papers were checked for relevance and duplication.

Downloaded information included author name(s), addresses, title, year of publication, abstract, and journal title. The records were downloaded into Excel software, and manual coding of authors' addresses was performed to identify different organizations. As the unit of investigation, each pair of unique organizations was recorded as one count of inter-organizational (or extramural) collaboration. Subsequently, if two or more authors in a paper were from an identical organization (though at times with different addresses), pairing among them was not considered as a case of inter-organizational collaboration and hence omitted from further analysis. The list of all identified organizations present in the dataset was then classified according to their political jurisdiction and institutional type. This resulted in 15 jurisdictional categories being identified in the analysis: US federal, Canada federal, eight Great Lakes states, Ontario (province), US states

outside the Great Lakes region, Canadian provinces outside the Great Lakes region, international locations (i.e., foreign-based, outside Canada or the USA), and inter-jurisdictional entities [e.g., the Great Lakes Fishery Commission (GLFC) and the International Joint Commission (IJC)]. For institutional types, we coded 11 categories—a US-based set of government, education, NGO/not-for-profit, private sector, and tribal/aboriginal institutions and an equivalent set for Canada, together with intergovernmental institutions (e.g., GLFC and IJC).

For inter-jurisdictional collaboration, the count of co-authorship pairs taking place over each pair of jurisdictional categories were summed and entered into a 15×15 adjacency matrix. A similar process generated an 11×11 adjacency matrix to compute all pairs of inter-institutional collaboration reported.

Results

Publication outputs, journals, and inter-organizational collaboration

Published papers on the Great Lakes were distributed over 683 unique journals between 2000 and 2014. Table 1 lists the top 10 journals in terms of the number of publications, with the *Journal of Great Lakes Research* overwhelmingly the largest venue with 813 papers (21% of the total output). The distribution of annual publication output over our study period is presented in Fig. 2. Both the total number of papers produced, and the number of inter-organizationally co-authored papers show an increasing trend over time, consistent with the contemporary expansion of scientific collaboration observed elsewhere (Adams et al., 2005; Glänzel and Schubert, 2005; Hickey, 2013; Melin and Persson, 1996). Table 2 lists the 20 organizations that produced the most inter-organizationally authored research on the Great Lakes. Three federal government agencies, the U.S. Geological Survey, Environment Canada, and the National Oceanic and Atmospheric Administration (NOAA, USA) ranked highest, with each publishing well over 200 papers in collaboration with other organizations. These organizations were closely followed by four US universities in the states of Wisconsin, Michigan, and Minnesota. The level of inter-organizational collaboration on Great Lakes scientific writing was generally high for each of the top 20 organizations, with at least 74% of the papers from each organization involving inter-organizational collaboration.

Inter-jurisdictional collaboration

The adjacency matrix created to analyze inter-jurisdictional collaboration was then mapped using VOSviewer1.6.0 (Van Eck and Waltman, 2014). Fig. 3 presents the resulting network of inter-jurisdictional collaboration in the form of density visualization. Node color indicates the level of collaboration for each jurisdiction (i.e., the redder the

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AND
(ABS ("Great Lakes" AND ("North America" OR "North American" OR Laurentian OR Canada OR Canadian OR US OR USA OR "United States" OR "St. Lawrence" OR Ontario OR Michigan OR "New York" OR Pennsylvania OR Indiana OR Ohio OR Illinois OR Wisconsin OR Minnesota)) OR ABS ("Lake Erie" OR "Lake Ontario" OR "Lake Superior" OR "Lake Huron" OR "Lake Michigan") OR ABS (lake* AND (Chicago OR Toronto OR Cleveland OR Detroit OR Buffalo OR Milwaukee OR Toledo OR "Grand Rapids" OR Hamilton OR Rochester)) OR TITLE ("Great Lakes" AND ("North America" OR "North American" OR Laurentian OR Canada OR Canadian OR US OR USA OR "United States" OR "St. Lawrence" OR Ontario OR Michigan OR "New York" OR Pennsylvania OR Indiana OR Ohio OR Illinois OR Wisconsin OR Minnesota)) OR TITLE ("Lake Erie" OR "Lake Ontario" OR "Lake Superior" OR "Lake Huron" OR "Lake Michigan") OR TITLE (lake* AND (Chicago OR Toronto OR Cleveland OR Detroit OR Buffalo OR Milwaukee OR Toledo OR "Grand Rapids" OR Hamilton OR Rochester)))

Fig. 1. Search terms used to generate published papers on Great Lakes-related science using the Scopus database (Elsevier, 2015).