Comment

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Can continental transboundary compacts hold water?

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The growing number of threats facing continental-scale transboundary water treaties warrants contemporary evaluation of not only the political and climatological conditions under which they were constructed, but also of how different management strategies for accommodating changes in those conditions can lead to treaty success or failure. We assess these threats by highlighting key attributes and vulnerabilities of water treaties across North America that frame a diverse set of future water management priorities. While these threats are ubiquitous globally, they are particularly pronounced in North America where water-abundant basins along the border between the United States (US) and Canada contrast with arid basins along the border between the US and Mexico. We propose addressing these needs through a three-step call to action for management agencies, politicians, and the public at large to embrace a holistic perspective on transboundary water agreements.

Continental transboundary water treaties and compacts face imminent threats related to climate change, migration, and increasing anthropogenic demand for freshwater[1]. In North America, divergent trends in regional water supplies and use rates across three prominent transboundary basins underscore these threats and warrant a holistic evaluation of (if not modifications to) long-term continental-scale sustainable water resources management.

For decades, residents of states (in both the US and Mexico) and other sovereign nations within and surrounding the basins of the Colorado River and the Rio Grande (Fig. 1) have struggled to allocate ever-diminishing supplies (Fig. 2A, B). This struggle is being exacerbated as chronic drought in the arid North American southwest worsens[2,3]. As if to punctuate an already strong gradient in continental water supplies, water levels on the Laurentian Great Lakes (along with outflows from the Great Lakes through the St. Lawrence River) rose to record highs between 2017 and 2020 (Fig. 2C) leading to widespread coastal inundation, flooding, and erosion[4].

Storms and flooding events in North American temperate regions are becoming more intense[5], and scientists believe that the recent swing from low to high water levels on the Great Lakes may foreshadow a future for the continental northeast characterized by pronounced hydrologic extremes[6]. These conditions, if they persist, will represent a new era for water resources management requiring holistic policies that focus not just on water scarcity, but on management of both water quantity and quality during periods of extreme and potentially harmful water abundance as well.

Contrasting continental compacts

The 1922 Colorado River Compact, the 1938 Rio Grande Compact, and the 1944 Water Treaty between the US and Mexico focus on allocating water extractions as a limited resource to specific claimants[3]. The Great Lakes–St. Lawrence River Water Resources Compact (hereafter simply the Great Lakes Compact), in contrast, was enacted in 2008 to restrict diversions of water from a basin characterized by variable but otherwise relatively abundant long-term water supplies[7]. For nearly two decades, the Great Lakes Compact has ensured that interbasin diversions, large volume withdrawals, and consumptive uses across the Great Lakes Basin are evaluated through a rigorous review process; it is arguably one of the most important transboundary water policy negotiations in recent North American history[8].

The climatological and hydrological context spanning the spatial divide between these transboundary agreements, however, is changing rapidly. Not only are many global water supplies diminishing[9], but the chronic drought and depleted water supplies of the arid southwest, coupled with increased flooding in the northeast, are setting the stage for a North American continental water crisis. In the epicenter of the continent, the Ogallala Aquifer (Fig. 1) is declining yet remains ungoverned by a multi-jurisdictional water management agreement that might slow its decline[10,11]. Even communities in close proximity to the Great Lakes Basin are, perhaps surprisingly, running out of water.

The City of Joliet (Illinois), for example, recently announced a decision to reroute its water supply from the Cambrian–Ordovician aquifer (Fig. 1)—a resource that, for over 150 years, served as a reliable source of groundwater for the midwestern United States—to Lake Michigan after recognizing that the aquifer was being depleted at an unsustainable rate[12]. Other proximal communities outside the Great Lakes Basin, such as Waukesha (Wisconsin), have requested diversions of Great Lakes Basin water because their local groundwater supplies are contaminated, albeit with naturally occurring radium[13]. These recent events are particularly paradoxical, if not troubling, in light of speculation by demographers that water abundance in the upper midwest may soon turn the region into a climate refuge[14].

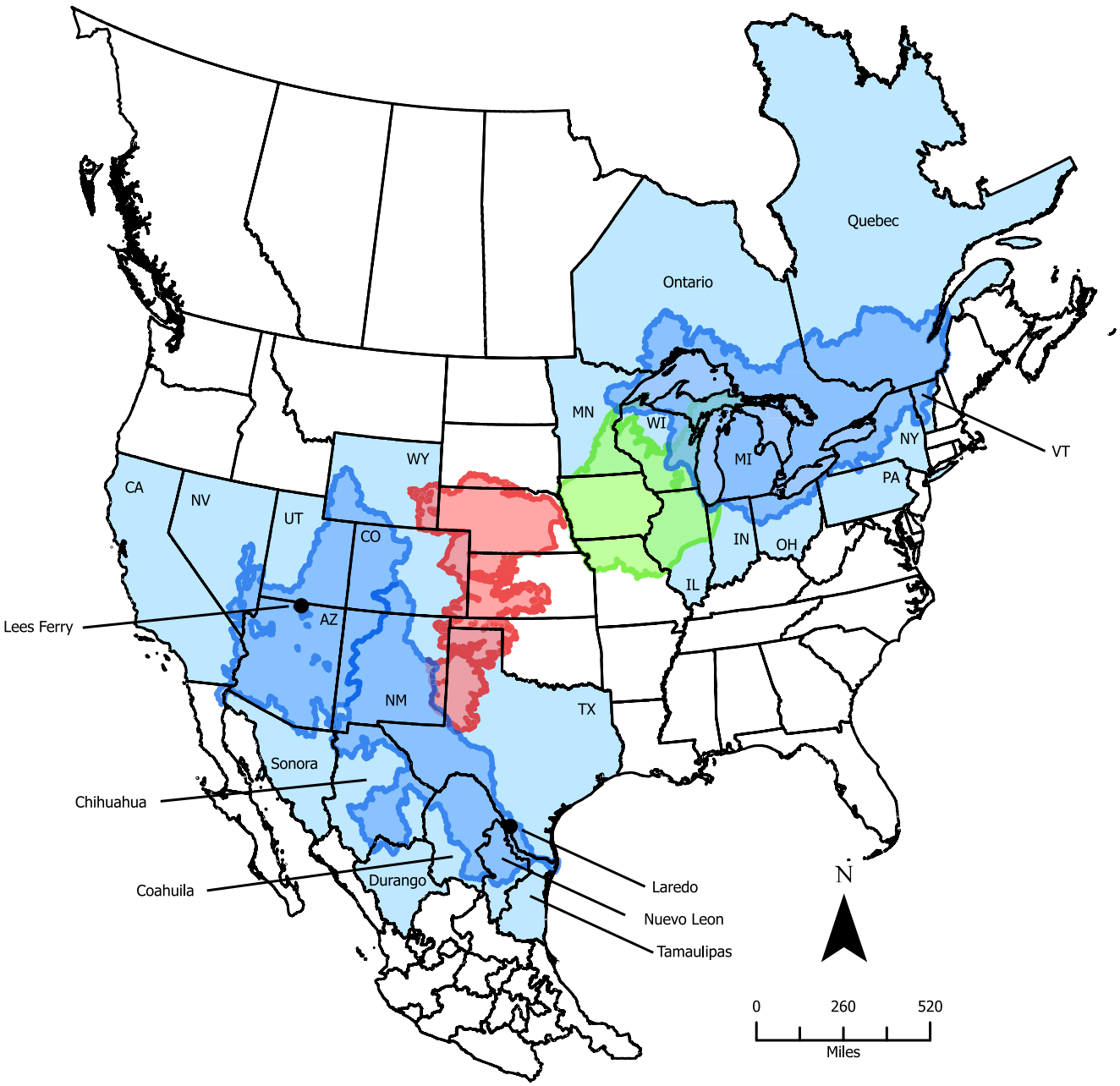

Fig. 1 | Map of central North America identifying transboundary basins (dark blue) of the Colorado River, the Rio Grande, and the Laurentian Great Lakes; states and provinces (light blue) within the US, Mexico, and Canada intersecting these basins; and the areal extent of both the Ogallala (red) and Cambrian-Ordovician (green) aquifers. Locations of the Lees Ferry (AZ) and Laredo (TX) flow monitoring stations (see Fig. 2) are also shown. North American political boundaries were obtained from: the Commission for Environmental Cooperation (CEC). 2021. "North American Atlas—Political Boundaries". Statistics Canada, United States Census Bureau, Instituto Nacional de Estadística y Geografía (INEGI). Available at www.cec.org/north-american-environmental-atlas/political-boundaries-2021/.

Linkages between compact failure, climate change, and management

Across North America (and around the world), there is reasonable concern about the durability of transboundary compacts under steepening spatial gradients differentiating regions of water abundance and scarcity. The transboundary compacts of North America underscore how the complex relationships between management practices, political stability, and climate-induced pressures (either through extreme scarcity or abundance) on regional water supplies can dictate their ultimate success or failure.

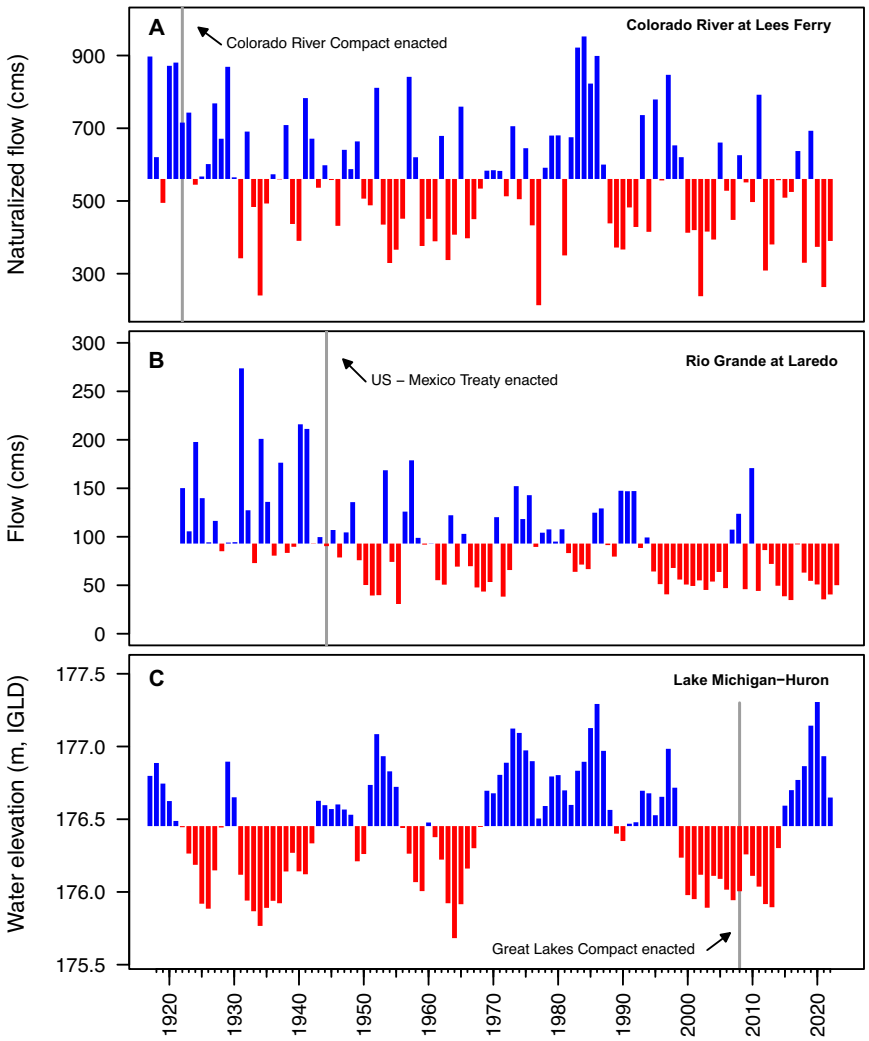

Fig. 2 | Annual average flows and water elevations from 1918 to 2022. On **A** the Colorado River at Lees Ferry (AZ), **B** the Rio Grande at Laredo (TX), and **C** Lake Michigan–Huron (Lakes Michigan and Huron are commonly considered one lake from a long-term hydrological perspective). Lake Michigan–Huron water elevations are relative to the International Great Lakes Datum (IGLD). Accurate flow records at Laredo began in 1923. Blue/red bars indicate years above/below the average over the period shown.

There are imminent calls, for example, to renegotiate the Colorado River Compact amidst that basin's ongoing aridification[15], and its longevity may hinge on the ability of a third party—the US Government—to reconcile interstate disputes and a legacy of overallocation. There is no comparable third party associated with the 1944 Treaty on the Rio Grande, and a political power imbalance between the US and Mexico limits the capacity of the Treaty's "Minute" process to fully accommodate diminishing regional water supplies associated with climate change.

The Great Lakes Compact has, in contrast (aside from a recently-approved exemption for diversions of water to Waukesha), been immune to freshwater demands from outside the basin; this success reflects the strength of carefully constructed language in the Compact itself, along with regional political stability. It is unlikely, however, that the Great Lakes Compact could survive if this stability were to devolve. Further, the Great Lakes Compact is vulnerable to divergent perspectives on the complex relationship between ecosystem health, short-term (i.e., discrete event-based) humanitarian needs, and water level variability. The successes of the Great Lakes Compact may therefore ultimately be moot if states, provinces, First Nations, or other entities, either within or outside the Great Lakes Basin (Fig. 1), declare a short-term humanitarian crisis as a basis for diverting Great Lakes water.

Moving forward

In light of these complex relationships, it seems logical and prudent for continental water management authorities to investigate three critical questions: (1) Will arid states and sovereign nations of the North American southwest be able to address water scarcity through renegotiation and amendments to the Colorado River Compact and US-Mexico Water Treaty alone? (2) Does the diminishing capacity of North America's large aquifers (including, for example, the Ogallala) warrant

new water resources management practices and coordinated multi-jurisdictional oversight? (3) In light of the continental gradient between scarcity and abundance, will compacts and treaties in water-rich regions (such as the Great Lakes) 'hold water' through the middle of the 21st century and beyond?

Addressing these questions requires three high-priority next steps. First, we recommend convening a summit of key compact and treaty organizational leadership to holistically assess compact and treaty vulnerabilities in light of ongoing and anticipated system changes. One potential vulnerability we anticipate is gravitation towards legalistic, top-down frameworks that might undermine collaborative relationships. These collaborative relationships and mutually beneficial negotiations characterized the founding of the Great Lakes Compact and, we argue, set it apart from other continental compacts and treaties.

Second, we recommend an in-depth review of the recent US Supreme Court decision in *Texas vs New Mexico and Colorado* to understand how it may influence other compacts and agreements when they diverge from federal interests. This review would address, and highlight for a broad audience, the challenges of designing transboundary water institutions that yield positive-sum, fair, and environmentally sustainable water allocations.

Third, we recommend further research, across the continental transboundary basins highlighted here and elsewhere, on long-term consequences of unmitigated (and perhaps increasing) water use under increasing climate-induced disruption to hydrologic regimes. Most compacts and treaties address a single basin. With the scale of threats expanding, new thinking is needed about the contours of, and potential role for, transboundary institutions that collectively address the needs and interests of multiple sovereign nations, states, and provinces at a multi-basin scale. In particular, research is needed to fully understand the range of consequences if inquiries into equitable renegotiations of existing compacts and treaties, or attempts to craft new compacts and treaties, are either investigated or dismissed.

We do not argue for extending the reach of the Colorado River Compact or the US-Mexico Water Treaty through expanded jurisdiction or extraction of new extra-basin water resources, nor do we argue for breaking the Great Lakes Compact by diverting excess water from the Great Lakes Basin. We are advocating for the long-term health and coincident sustainability of multiple continental freshwater systems by urging policymakers to clearly articulate and reiterate the history of existing compacts, and to address their strengths and weaknesses, within continental and global water resources management contexts.

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Author contributions

A.G. contributed to manuscript conceptualization, graphics, project administration, and technical writing. V.R. contributed to manuscript conceptualization, graphics, and technical writing. J.B., M.C., M.M., and J.A. contributed to manuscript conceptualization and technical writing.

Competing interests

The authors declare no competing interests.

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