THE GREAT LAKES FUTURES PROJECT

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"Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it's the only thing that ever has." Margaret Mead, 1901-1978

INTRODUCTION

The Great Lakes community is focusing global attention on the importance of freshwater and advocating sustainable management for its freshwater resources. The Great Lakes-St. Lawrence River basin alone holds 21% of the world's surface supply of freshwater. There are serious issues at the interface between two conflicting societal pressures: increasing water need, both by a growing population and more intensive enterprises to support this population and a decreasing and deteriorating water supply. Yet many people still deal with the Great Lakes basin as a limitless water resource. For the sake of future generations, the Great Lakes community cannot afford to be naïve or complacent. Haphazard decision-making and ill-conceived governance can destabilize our use of these shared resources, placing our personal and economic health at risk. We need eyes on the waters of our Great Lakes basin. They don't make Great Lakes anymore.

THE NEED FOR A DIFFERENT APPROACH

The Great Lakes community recognizes the need for cooperation in the management of our water resources; and in this regard, Canada and the US are global leaders. Cooperation between Canada and the US on the Great Lakes basin has a long, rich and successful history. One example, as argued by Regier et al. (this issue) was the Great Laurentian Spring of 1968-1993, marked by the coming together of government agencies, relevant commissions, university-based researchers, citizens' organizations, industry representatives and churches around the protection of the basin. During this Spring, networks were informed by ecosystem science and a strong emphasis on stakeholder participation, transparency and public accountability (Krantzberg et al., 2000). However, past cooperative initiatives in the Great Lakes were born largely out of reactions to serious problems confronting the basin. For example, the Great Lakes Water Quality Agreement of 1972 was established in response to public outcry after the polluted Cuyahoga River caught on fire in 1969. Over the 40+ years that have passed since the signing of that first agreement, other challenges arose. Some , more recent examples of these challenges are changing agricultural practices that have led to recently increased phosphate inputs to Lake Erie and resulting algal blooms, increasing concerns about dead zones, as well as ballast ship water exchange issues that supported the introduction and proliferation of many destructive invasive species such as the zebra mussels, and quagga mussels added to earlier invaders like the sea lamprey. There are new challenges

facing us today – including the recent concerns about toxin-producing algal blooms that have left water supplies undrinkable, forcing Great Lakes residents to turn to bottled water despite living next to one of the greatest freshwater water bodies of the world.

A committed bi-national group of researchers has initiated a forward-looking approach, proactive approach to managing the Great Lakes. The Transborder Research University Network (TRUN) for Water Stewardship was started in 2010 as an international, interdisciplinary research network comprising 16 Canadian and US institutions committed to innovative research, training, and engagement on issues affecting the Great Lakes basin. The inaugural collaborative activity undertaken by the TRUN for Water Stewardship was "The Great Lakes Futures Project" (GLFP),the intellectual venture that brings forth this special issue.

SCENARIO ANALYSIS – A CATALYST FOR NEW BEGINNINGS

The GLFP has used scenario analysis to make predictions on plausible futures of the Great Lakes basin and to form focused questions concerning the foreseeable pressures being placed on these water bodies, and what may be the unintended consequences of society's actions or inactions? Scenario analysis as a method presents an exciting, important, valuable, yet underutilized tool within the Great Lakes basin. As argued by Laurent et al. (this issue, a) scenario analysis can complement management strategies, because it: (1) is "a rigorous approach to transcending disciplinary boundaries; (2) enables the consideration of uncertainty; (3) creates a common language among science-policy-stakeholder representatives, adding diversity and depth to the science-policy discourse; (4) can be customized and applied at local, regional, national, binational, continental, and global scales; and (5) provides a foundation for asking strategic research questions and can contribute to effective management strategies".

In conducting this scenario analysis, the GLFP asked if the future unfolds in a certain way, what can we do about it? We. Canadians and Americans. We. Government, industry, the academy, and private citizens. We. Scholars from the many different disciplines including natural sciences, social sciences, engineering, medical sciences, law, and economics. By taking a scenario analysis approach and analyzing the multifaceted drivers of change impacting the basin, the GLFP created a space where the necessary "We" could come together to explore alternate and plausible futures.

SCENARIO ANALYSIS – DRIVERS, AXES AND FUTURES

The GLFP scenario analysis was based on a 100-year time period, from 1963 to 2063; a time period that represents 50 years before and 50 years after the GLFP was conducted, and a spatial scale that included the air and watersheds of the entire Great Lakes basin.

Through expert engagement and breakout discussion at its inaugural workshop, the GLFP identified eight drivers of change impacting the Great Lakes basin (Laurent et al., this issue, b). These drivers included climate change, water quantity, demographics and societal values, the economy, energy, biological and chemical contaminants, aquatic invasive species, and governance and geopolitics. These drivers were selected as the eight "key" drivers among the many drivers proposed by GLFP participants. We would have liked to include the drivers of human health and technological innovation but did not due to the reality of budget constraints; we encourage others interested in ecosystem-related scenario analysis to do so.

Since 1963, climate change within the basin has been manifested in the form of increased water temperatures and a higher magnitude and frequency of precipitation events, with future projections indicating that these climatic trends will continue with the potential to have extreme effects (Bartolai et al., this issue). The Great Lakes basin has experienced an increase in over-lake precipitation, runoff and evaporation. Although each of these parameters has increased over time, the overall volume of water within the Great Lakes has been in decline. As such, the changes in Great Lakes water levels have had significant impacts on the basin's population and ecosystem. These impacts will continue to impact the region into the future; and if current trends in climate continue, the lakes will experience lower levels (Maghrebi et al., this issue).

Under this changing climate, the human population of the Great Lakes basin has increased (reaching 48.5 million in 2011), become older (a result of both decreasing fertility and increasing life expectancy matched by an aging baby boomer population), and diversified (immigration to the basin makes up a large share of the population growth). However, the basin's population is growing in size mainly due to increases on the Canadian side, whereas many US cities are experiencing a major decline in their populations. The trends in societal values of Americans and Canadians have also changed in recent years, marked by the US society becoming more materialistic and the Canadian society less materialistic. If growth within the basin remains consistent with rates in the US (0.25% per annum from 1990 to 2010) and in Canada (1.5% per annum from 1991 to 2011), the population of the Great Lakes basin could increase by 26% relative to the 2010/2011 levels and reach 62.6 million by 2063. Demographic change and societal values are core drivers of socio-ecological change and so are critical to consider when exploring basin futures (Méthot et al., this issue).

The Great Lakes region became an important economic engine generating considerable wealth due to its abundant natural resources, efficient transportation system, binational economic integration via supply chains, and its reputable higher education system. However, the region's economy is under transition and is uncertain. To sustain its historical success, investments within the basin should be made in education, infrastructure, new high-growth manufacturing, and environmental restoration (Campbell et

al., this issue).

To support this growing population and economic activity, there was an increase in energy demands, and also a shift from conventional (mainly coal, oil, conventional natural gas, nuclear, and hydroelectric power) to more renewable energy sources has occurred to meet these demands. Over the past 50 years the US obtained the majority of its electricity from coal-fired power plants, whereas Canada obtained a majority of its electricity from hydroelectricity. Recent trends show that renewable electricity production (such as wind production and solar photovolatics) is on the rise in the basin, supported by government incentives such as tax credits, grants and feed-in-tariff systems. However, the development of unconventional sources of natural gas (through hydraulic fracturing or fracking) poses new risks on the basin (Kelly et al., this issue).

The combination of climate change and rapid economic growth has resulted in challenges related to ecosystem health. For example, conventional and emerging contaminants have and continue to pose serious threats to ecosystem health within the Great Lakes basin (Cornwell et al., this issue). Furthermore, the Great Lakes basin has been significantly invaded by non-native species making the region the most invaded freshwater system in the world. These invasions are predicted to intensify, placing greater stress on the already stressed basin (Pagnucco et al., this issue). In the face of these and many other changes, governance has become a pernicious problem. Institutional fragmentation, governance capacity, and the changing relationships between federal and sub-national levels of both Canadian and US governments have placed at risk the sustainability of the Great Lakes region. In light of the cumulative effects of the aforementioned drivers such as climate change, changing economic and demographic conditions and the potential for scarcity of safe and reliable water supplies, the governance challenges are likely to be intensified (Jetoo et al., this issue).

The GLFP distilled the drivers of change into two independent forces of high impact and high uncertainty to frame four alternative futures in the year 2063 (Laurent et al., this issue, b). Informed by diverse stakeholder engagement (e.g., academia, government, non-governmental organizations, and industry organizations), two independent forces were selected including “Human Capacity for Change” and “Environmental and Economic Balance”. On the positive ends of the axes, the “Human Capacity for Change” denotes an adaptive system where shared values, collectivism, inclusivity, and a respect for obligations are a reality, and the “Environmental and Economic Balance” denotes a system where a synergy exists between economy and environment. On their negative ends of the axes, the “Human Capacity for Change” denotes a reality where society is individualistic, overly hierarchical, shortsighted, reactionary, oppressive, and governed by a gridlocked governance system, and the “Environmental and Economic Balance” denotes a system where the environment, economy, or both are in poor shape. For the GLFP, the selection of a force encompassing a balanced environment and economy provided a novel

perspective on the intimate connection between the two parameters, parameters often considered independently, and the need to consider both in order to achieve a thriving basin. The intersection of these two independent forces framed four very distinct future scenarios for 2063.

The poor "Human Capacity for Change" and poor "Environmental and Economic Balance" scenario (negative x – negative y) was entitled "Out Of Control: How We Failed To Adapt And Suffered The Consequences" (Kalafatis et al., this issue). In this future scenario, society was characterized as shortsighted and narrow-minded, unable to make the necessary changes to successfully navigate the challenges of the future, including continued environmental crisis and self-interested exploitation. The region, once a leader in cross-border governance, experienced a failure in governance due to an inability to both respect and effectively incorporate the interconnectedness of the economy with the environment. Insufficient planning, funding, and research rendered the basin ill prepared for the future and overall the basin and its residents suffered.

The poor "Human Capacity for Change" and good "Environmental and Economic Balance" scenario (negative x – positive y) was entitled "Living On The Edge: How We Converted Challenges Into Profitable Opportunities" (Steenberg et al., this issue). In this future scenario, the basin is at a tipping point beyond which system failure would occur, a position driven by reactive policy formulation, dependency on the global economy and technological innovation, coupled by aggressive pro-business policies and private-sector intellectual capital. The delicate balance between the economy and the environment was based solely on external factors (e.g., positive global market forces) rather than internal factors (e.g., good governance). Poor governance and little human capacity to affect change plagued the region, internal decision-making was ineffective, and cooperative federalism across the region dissolved.

The good "Human Capacity for Change" but poor "Environmental and Economic Balance" scenario (positive x – negative y) was entitled "Trying Hard To Adapt To A Chaotic World: How Complex Challenges Overwhelmed Our Best Intentions" (Orr et al., this issue). In this future scenario, society had a strong will to change to meet the needs of a new economic and environmental reality in the basin, but difficult trade-offs had to be made and people suffered. The governance system had great capacity, but despite cohesive efforts, the multiple, complex and interacting pressures on the basin overwhelmed best intentions. Geopolitical, economic, demographic and climate pressures such as environmental refugees, an aging population, and a sluggish economy, occurred at a rate too rapid and of too great a magnitude for the region to adapt, placing the basin in an extremely vulnerable position.

The good "Human Capacity for Change and good "Environment and Economic Balance" scenario (positive x – positive y scenario) was entitled "Thriving And Prosperous: How We Rallied To Confront Collective Challenges" (Comer et al., this issue). In this future scenario, society was guided by a

common set of policy principles and cooperation among residents, non-government organizations, academic institutions, government, and industry. A healthy and protected environment was supported by and balanced with a thriving economy, where government and industry action was informed by research and strong public participation in decision-making.

There was a strong sentiment among the GLFP participants that our current policies are leading us towards an undesirable future. One of the main conclusions of the GLFP was that current policies could not cope with the increased pressures impacting the basin. Some felt that we are heading towards the negative-positive ("Living on the Edge"); whereas others were more cynical and felt we are heading towards (or are already in) the negative-negative ("Out of Control"). Generating the scenarios created a space to explore the future towards which our current policies were leading us, and the policy changes that would be needed to lead us to the desired future, a "Thriving and Prosperous" Great Lakes region.

HOW DO WE ACHIEVE MORE EFFECTIVE POLICIES?

Friedman et al. (this issue) describes barriers to effective policy within the Great Lakes region identified in the GLFP that include:

(1) Great Lakes policies are fragmented vertically and horizontally across scale and jurisdiction.
(2) Great Lakes policies are fragmented substantively, lacking a holistic approach.
(3) Policy implementation is hindered by inadequate capacity, accountability, and enforcement.
(4) Adaptive management remains elusive.
(5) There is a collapse of Canadian support for investment in Great Lakes research and education.
(6) The Great Lakes basin lacks a shared vision for the future.

To overcome these barriers, there was recognition that "Stakeholders should leverage the fact that the Great Lakes basin is a policy system characterized by shared power, many actors, ambiguity, complexity, and flexibility". Five policy considerations that would result in a "course correction", leading us to a more desirable future were identified:

(1) Seek out opportunities to develop management strategies, mechanisms and practices that are place-based and require shared responsibility for the Great Lakes basin.
(2) Create and build upon existing mechanisms that embody ecosystem health as a foundation that leads to societal well-being.
(3) Develop and monitor indicators of comprehensive ecosystem health.
(4) Strengthen existing and create new Great Lakes experiential programs.
(5) Develop stakeholder-driven planning and visioning that is legitimized by political leadership both

before and after planning to nurture a Great Lakes "citizenship" or "identity".

Krantzberg et al. (this issue) argued that mechanisms are necessary to engage and mobilize the Great Lakes basin citizenry to demand that the federal governments develop of collaborative programs and policies that build coordinated community capacity. These mechanisms included: (1) the identification of basin-wide, cross-sector, inclusive visions, goals, objectives, and tactics; (2) the increased roles and responsibilities of local community groups, governmental and non-governmental organizations, to provide a better balance between top-down and bottom-up efforts; and (3) the engagement of the full regional citizenry in both of the above.

Three possible future trends were considered within each of the GLFP driver papers: "Status Quo", "Dystopian" (worst-case trend), and "Utopian" (best-case trend), and recommendations were made by the authors that guided us to Utopia (Table 1). These recommendations, in addition to the four alternate scenarios of the GLFP, revealed potential strategies to reach a desired future that could be explored and considered for the basin (Table 1). A specific example of the potential that exists to contribute to a positive future trend was provided by the Detroit River International Wildlife Refuge (DRIWR), where the DRIWR's cooperative agreement and voluntary initiative approach fostered capacity building and led to stakeholder recruitment and retention, securing of project resources, building of public-private partnerships, an achievement of legitimacy and a cultivation of local ownership for the DRIWR (Hartig, this issue).

LESSONS TO GUIDE US TOWARDS A "THRIVING AND PROSPEROUS" FUTURE

Sandford (this issue) warned that in order to reach a "Thriving and Prosperous" future, we need to consider and navigate the following seven "lessons learned" from the GLFP (and other great lake systems). The lessons include: (1) "Without legal teeth and clear accountability, even the best-intentioned agreements won't work". This lesson highlights the idea that many of the environmental insults of the past could have been avoided if the Great Lakes regional binational agreements had been legally binding from the outset rather than voluntary; (2) "Getting it done is different than keeping it done". This lesson highlights the challenge as to how tired, worn-out relations and interests, whose long-term efforts have proven to fall short of solving the problem, be revived; (3) "Ineffective public engagement is the kiss of death". Public engagement is key to the achievement of sustainable water governance initiatives"; (4) "The Federal Government has responsibilities in addition to powers". A highly mobilized coordinated top-down and bottom-up process is critical for the nested watershed approach required to address the extent of multiple stressors impacting the Great Lakes region; (5) "The promise of funding is not the same as actual funding". Without proper funding for critical restoration and engagement initiatives within the

basin, volunteer burnout, frustration and, ultimately, hopelessness will result and the basin will suffer; (6) "We urgently need leadership". In order to sustain the health of the Great Lakes, leadership is required at all levels of society, from the top to the bottom. (7) "It can be done". The GLFP has shown that the worst-case scenario can be avoided, but only through immediate action, action urgently required before the basin's challenges overwhelm to the point that they are unable to be addressed (Sandford, this issue).

THE FUTURE OF THE GREAT LAKES FUTURES PROJECT

At the final GLFP Phase I workshop, held on October 3rd, 2013 at the State University of New York at Buffalo, stakeholders were asked to consider and rank the GLFP Phase I policy considerations to inform strategic implementation. When asked which of the policy considerations was the most important to implement, stakeholders recognized the first, to develop place-based and shared responsibility strategies (27%, Figure 1). When asked which of the considerations is the most doable, the consideration identified as the most important was also recognized as the hardest to achieve (Figure 2). Based on GLFP stakeholder feedback, it is clear that to develop place-based and shared responsibility strategies is an important consideration to facilitate the necessary "course correction" for the basin. Not only is this consideration important, it is also difficult because as GLFP stakeholders suggested: (1) the basin's policies currently encompass different mandates for federal, state, provincial, and municipal governments; (2) there is no policy space to accommodate both top-down and bottom-up perspectives, and; (3) although the annexes of the 2012 Great Lakes Water Quality Agreement (GLWQA) do identify the risks to the basin, they do not address their management (Friedman et al., this issue). Therefore, a critical need exists to create a "space" where both "top-down" (i.e., regulatory) and "bottom-up" (i.e., volunteer) approaches can be taken to manage the risks facing the basin.

In the next phase of the GLFP, we will embark on an exciting journey to work with decision makers to assess the "risks" associated with contemporary management strategies, and to recommend changes to reduce these risks. We will take a strategy that will reveal the strengths, weaknesses, opportunities, and threats of existing regulatory and voluntary mechanisms operating in the basin. This strategy will recognize the critical role of international, federal, provincial/state and municipal governments in their shared mandates for the management of the Great Lakes basin. It will also recognize the need to incorporate mechanisms to motivate those at the operational level, those "in the trenches" at the community level. Furthermore, it will be applicable to a wide range of issues impacting the Great Lakes basin.

The next phase of the GLFP will showcase to decision-makers how an internationally recognized standard for risk management can be applied to the Great Lakes ecosystem. The International

Organization for Standardization (ISO) 31000:2009 Risk Management Standard (ISO, 2009) has been customized to provide a systems approach to risk management, where system risks are assessed and resources are deployed to areas experiencing the highest risk potential (Cormier et al., 2013). As part of the ISO 31000:2009 suite of standards, the Bowtie Method (Figure 3) is one of the few assessment techniques of the standard that takes a systems approach to the analysis of management measures within a policy context (IEC/ISO, 2009). We will adopt the ISO 31000 Risk Management Principles and Guidelines (ISO, 2009) and the Bowtie Method (IEC/ISO, 2009) for analyzing risks with the intent of showcasing to relevant organizations how these tools can be appropriate for assessing cumulative effects of multiple stressors within the Great Lakes basin. We will demonstrate opportunities for enhancement of current management strategies of the renegotiated 2012 Great Lakes Water Quality Agreement (GC and USFG, 2012) to achieve its general purpose, to maintain the physical, chemical and biological integrity of the waters of the Great Lakes basin. GLFP stakeholders will be involved in every phase of this project, and we will adopt both a top-down and bottom-up approach. The top-down component will involve working with decision makers to identify mechanisms such as agreements, acts, legislation, regulations, and standards for reducing the ecosystem and human health risks impacting the Great Lakes basin. The bottom-up component will involve working with community groups to identify water values, evaluate voluntary mechanisms, such as best management practices, and explore how education can influence the compliance and effectiveness of adoption of best management practices. By combining these two approaches, we will think creatively about "middle-out" approaches (Friedman et al., this issue) and aid in the "course correction" so badly required.

CONCLUSION

Despite a century of treaties and agreements, the Great Lakes basin continues to show signs of deterioration, with new challenges confronting these waters. Current approaches are insufficient to lead decision-makers to handle future issues. We are facing a time when proper governance and management are evermore critical to promoting a thriving basin. Reactionary policies are not good enough. We must be proactive. We must be cooperative, with a vision of sustainability.

The GLFP was a unique project like no other in the Great Lakes basin and resulted in a showcase of the value of scenario analysis for approaching resource management and engaging diverse stakeholder groups to reach future sustainability. Laurent et al. (this issue, a) suggested that the GLFP allowed us to consider the future that our policies are leading us to, and the policy alternatives that will result in a "course correction", leading us towards a "Thriving and Prosperous" Great Lakes basin. The GLFP created a space for bridging disciplines, a space where members from different disciplines could come

together to map policies and priorities that foster future sustainability within the basin. This was accomplished by the participatory approach that defined the project. This approach allowed knowledge and understanding to be co-produced by diverse communities, who were drawn together by their passion and concern for the Great Lakes basin, and spanned the boundary between science and policy. This participatory process also provided a learning opportunity that enabled a richer consideration of the issues facing the Great Lakes basin (Williams, this issue).

The next phase of the GLFP will reveal how current efforts to develop and implement measures to protect the physical, chemical and biological integrity of these waters can be streamlined, energized, and their efficiency analyzed. The next phase of the GLFP presents an exciting opportunity to explore management strategies and reflect upon values that will result in the necessary "course correction" identified by GLFP Phase I, a "course correction" to lead the basin to a "Thriving and Prosperous" future (Comer et al., this issue). We anticipate presenting the outcomes of this next phase of the GLFP in a future issue of the *Journal of Great Lakes Research*!

In an era of cooperation and collaboration on water issues, positive agents are already active. The GLFP participants are stewards of the basin and are dedicated to providing leadership that will ensure that the Great Lakes remain great for our generation and future generations to come. Raise a glass, Great Lakes stewards. Sing the water song and commit to being not just "hewers of wood and drawers of water", but maestros of our destiny.

ACKNOWLEDGEMENTS

The GLFP was a grassroots effort, entirely dependent upon the commitment and passion of those involved in protecting the Great Lakes-St. Lawrence River basin. It gained traction and momentum when Dr. Ted Hewitt, Western University's then-Vice President of Research, secured seed funding for the GLFP from Canadian and US university administrative offices. This was leveraged to garner further support for this binational and transdisciplinary initiative. Dr. Irena F. Creed of Western University, Canada, led the GLFP along with colleagues Dr. Gail Krantzberg, McMaster University, Dr. Kathryn Bryk Friedman, University at Buffalo, SUNY, and Dr. Donald Scavia, University of Michigan. Dr. Katrina Laurent was hired to be project manager. In this capacity, Dr. Laurent led fundraising efforts, managed participating graduate students and faculty mentors, organized and managed GLFP workshops, and participated in the research activities of the GLFP. In addition to the leadership team and project manager, the GLFP involved graduate students, academics, government, non-government organizations, and industry representatives from Canada and the US, evolving to include more than 50 binational research teams and 100+ participants.

Since the TRUN for Water Stewardship launched the GLFP, the following 22 research organizations have provided support in Canada – McGill University, McMaster University, Ryerson University, Seneca College, Queen's University, Trent University, University of Guelph, Université de Montréal, Université du Québec à Trois-Rivières, University of Toronto, University of Waterloo, University of Windsor, Western University, York University, and Environment Canada, and in the US – University at Buffalo SUNY, University of Michigan, Michigan State University, Wayne State University, Michigan Sea Grant, New York Sea Grant, and Great Lakes Fishery Commission. Overall, approximately $250,000 was raised to fund this interdisciplinary initiative.

The GLFP flourished through the hard work and creativity of its students. Twenty-seven graduate students participated in binational research teams, including those from Canada – Maureen Campbell, University of Windsor; Jean Olivier Goyette, Université de Montréal; Frazier Fathers, University of Windsor; Shannon Fera, Trent University; Elaina Hurst, McGill University; Savitri Jetoo, McMaster University; Brianne Kelly, University of Waterloo; Josée Méthot, McGill University; Deasy Nalley, McGill University; Christopher Orr, McGill University; Katie Pagnucco, McGill University; Ryan Sorichetti, Western University; Sophie Splawinski, McGill University; James Steenberg, Ryerson University; Adam Thorn, Ryerson University; and from the US – Alana Bartolai, University of Minnesota; Bryan Comer, University at Syracuse, SUNY; Matthew Cooper, University of Notre Dame; Emily Cornwell, Cornell University; Lingli He, University of Michigan; Xiyu Huang, University at Buffalo, SUNY; Scott Kalafatis, University of Michigan; Bonnie Keeler, University of Minnesota; Mahdi Maghrebi, University at Buffalo, SUNY; George Maynard, University at Plattsburgh, SUNY; Michael Timm, University of Wisconsin-Milwaukee; Kathleen Williams, University of Wisconsin-Milwaukee. We also welcomed the creative talents of Andrea Guzzetta (AMG artistry) who helped bring our scenarios to life through her artwork.

Great Lakes experts were generous with their time, energy, and enthusiasm while mentoring these young leaders. Twenty-nine mentors guided the graduate student research teams, including those from Canada – William Anderson, University of Windsor; James Bruce, International Upper Great Lakes Study; Irena Creed, Western University; Peter Dillon, Trent University; Monica Gattinger, University of Ottawa; Gail Krantzberg, McMaster University; Katrina Laurent, Western University; Warren Mabee, Queen's University; Roxanne Maranger, Université de Montréal; Linda Mortsch, University of Waterloo; Robert Paehlke, Trent University; Anthony Ricciardi, McGill University; Pamela Robinson, Ryerson University; Paul Sibley, University of Guelph; William Taylor, University of Waterloo; the exceptionally wonderful and gracious Charles Trick, Western University; Norman Yan, York University; and from the US – David Allan, University of Michigan; Joseph Atkinson, University at Buffalo, SUNY; Jonathan Bulkley, University of Michigan; Kathryn Bryk Friedman, University at Buffalo, SUNY; Sara Gosman,

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This special issue reflects the combined work of all of these people. Through 18 months of meetings and countless correspondences, this work was translated into four workshops and the 16 papers and four commentaries in this GLFP special issue. This special issue was made possible by the support of the co-editors of the International Journal of Great Lakes Research (Robert Hecky and Stephanie Guildford) who believed in this project, the guest editors of this special issue (Irena Creed together with Katherine Bunting-Howarth, Marc Gaden, Valerie Luzadis, Paul Sibley, William Taylor), and the tireless efforts of many reviewers.

The GLFP is continuing in the form of a related project called the Great Lakes Action Plan for Sustainability. With support from a Knowledge Mobilization Grant from the Canadian Water Network, this project will bring together researchers and end users (who use the research for decision-making) to develop mechanisms that address the major recommendations coming out of the GLFP, which are relevant to the decision making context and will encourage uptake and application. The results of the Great Lakes Action Plan for Sustainability will hopefully be shared in a future issue of the Journal of Great Lakes Research.

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Table 1. Recommendations for management strategies that will move us towards a "Thriving and Prosperous" future.

Driver	Recommendations
Overarching	• Foster a knowledgeable and engaged society. • Develop an adaptive management approach to address drivers of change. • Improve a basin-wide environmental monitoring network, using data and model-based monitoring tools to understand current and predict future system states. • Use risk management techniques to inform management decisions. • Support and cultivate effective and efficient binational coordination between Canada and the US. • Build strong collaboration between stakeholders. • Engage broad-spectrum stakeholders in management decision-making. • Ensure that infrastructure upgrades are supported and consider appropriate basin drivers.
Climate Change	• Implement immediate and sustained mitigation and adaptation strategies. • Reduce energy consumption through energy conservation, fuel efficiency and reduced emissions. • Create a unified carbon market across the basin. • Ensure proper emergency planning and preparation for dealing with regional disasters. • Investment in energy conservation, efficiency, and infrastructure to boost the economy of the region and reduce costs in the long term.
Water Quantity	• Adopt a systems approach to improve understanding the interrelationships among the natural and anthropogenic factors influencing basin water levels.
Demographics and Societal Values	• Improve understanding of the effects of an aging population on basin dynamics. • Improve understanding of how a growing immigrant population will influence the basin's societal values and political trends. • Improve understanding of how societal values will impact future sustainability action. • Explore how smart growth or smart shrinkage will impact social-ecological resilience basin-wide.
Economy	• Support federal and state expenditures to bolster infrastructure. • Focus capital investments on re-tooling of manufacturing plants to produce products with global demand. • Ensure that environmental policies lead to clean and restored ecosystems. • Continue to invest in education and technical training to produce highly qualified personnel with the necessary skill set to drive innovation in the region's future economy.
Energy	• Consider environmental conditions when developing future energy plans. • Encourage increasing the capacity of renewable energy on both sides of the border. • Include in policy objectives for renewable energy the development of emerging technologies, including offshore wind, solar photovoltaics and small-scale, run-of-river hydroelectricity. • Include in policy objectives for energy production consideration of both greenhouse gas emissions and water resource impacts.
Biological and	• Provide incentives for responsible manufacturing, site restoration, and innovation

Chemical Contaminants	to support and foster a green economy. • Upgrade and maintain wastewater treatment plants and support programs such as water supply infrastructure renewals. • Develop new techniques to identify and track both conventional and emerging biological and chemical contaminants. • Explore microbial source tracking to understand biological contaminants. • Use an integrated assessment approach and multiple tools to predict and manage risks and understand their complexities.
Invasive Species	• Invest in preventative and cost effective invasion prevention efforts. • Establish a harmonized Canadian and US policy framework for early detection and rapid response. • Establish harmonized live trade legislation. • Coordinate efforts across all relative fronts among legislators, educators, and scientists to manage invasion threats.
Governance and Geopolitics	• Increase and encourage cooperation between jurisdictions to overcome the institutional fragmentation. • Strengthen relationships between provinces, states, and their respective federal governments. • Increase funding for Great Lakes protection and institutionalize stakeholder engagement. • Recommit to the binational character of the International Joint Commission.

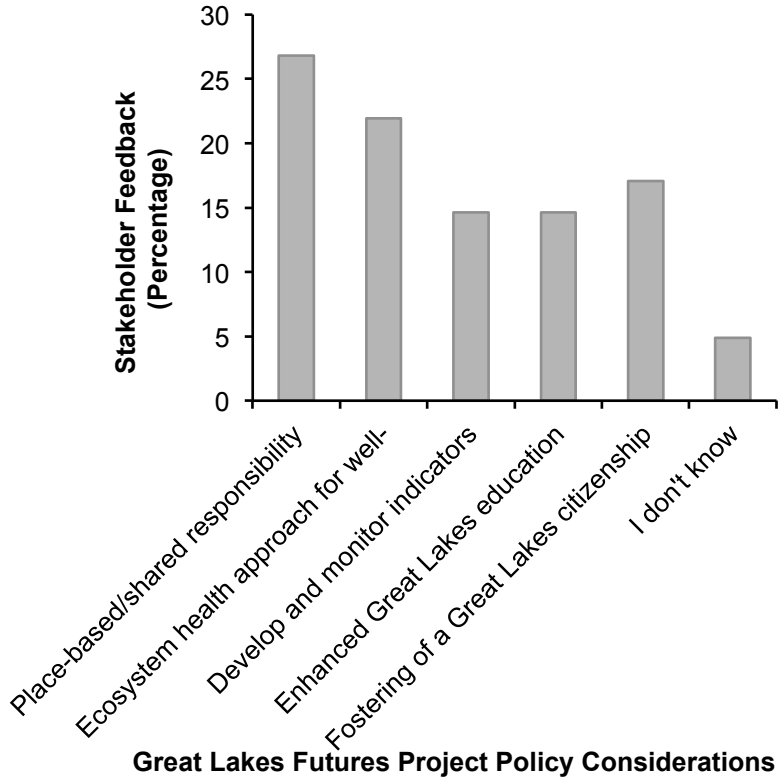

Figure 1: Stakeholder feedback on which of the Great Lakes Futures Project (GLFP) Phase I policy considerations are the most important for implementation. Stakeholders were asked to select from the following considerations: Develop place-based/shared responsibility strategies; Take an ecosystem health approach to support societal well-being; Develop and monitor indicators; Foster Great Lakes experiential programs; and build stakeholder confidence to nurture a Great Lakes citizenship.

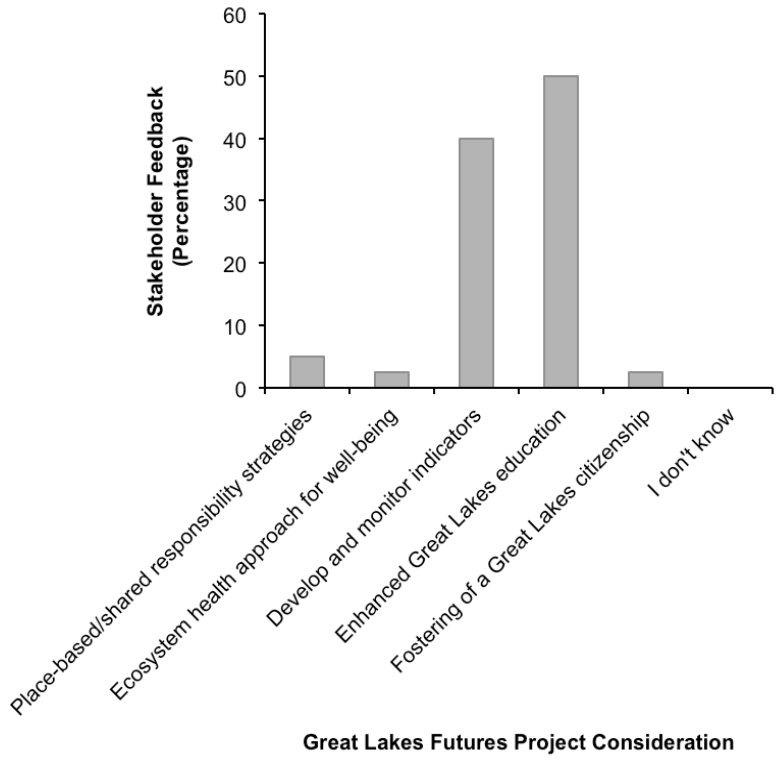

Figure 2. Stakeholder feedback on which of the Great Lakes Futures Project (GLFP) Phase I policy considerations are most achievable. Stakeholders were asked to select from the following considerations: develop place-based/shared responsibility strategies; take an ecosystem health approach to support societal well-being; develop and monitor indicators; foster Great Lakes experiential programs; and build stakeholder confidence to nurture a Great Lakes citizenship.