Journal of Great Lakes Research 41 Supplement 1 (2015) 131–138

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

Critical forces defining alternative futures for the Great Lakes–St. Lawrence River basin ☆

Katrina L. Laurent† [a,*], Donald Scavia† [b,1], Kathryn B. Friedman [c,2], Gail K. Krantzberg [d,3], Irena F. Creed [a,4]

[a] Department of Biology, Western University, 1151 Richmond St. London, ON N6A3K7, Canada
[b] Graham Sustainability Institute, University of Michigan, 625 E. Liberty St., Ann Arbor, MI 48104, USA
[c] University at Buffalo Regional Institute, The State University of New York, UB Downtown Gateway, 77 Goodell Street, Suite 302, Buffalo, NY 14203, USA
[d] Centre for Engineering and Public Policy, McMaster University, ETN 510 1280 Main Street W., Hamilton, ON L8S 4L7, Canada

ARTICLE INFO

Article history:
Received 24 October 2013
Accepted 27 March 2014
Available online 5 January 2015

Communicated by Paul Sibley

Index words:
Scenario analysis
Impact
Uncertainty
Critical forces
Human capacity
Environment/economy balance

ABSTRACT

Envisioning possible futures is challenging due to the interactive and interdependent nature of myriad anthropogenic pressures on the Great Lakes–St. Lawrence River basin. To overcome this challenge, we used the intuitive logistics method of scenario analysis and identified two independent forces of high impact and high uncertainty by engaging a broad spectrum of basin stakeholders from academia, government, non-governmental organizations, and industry organizations. A workshop was held to debate and identify the two key forces among many drivers of change for the Great Lakes–St. Lawrence River basin. From the workshop activities, two key forces emerged. The first axis, "Human Capacity for Change," was characterized on its positive end by an adaptive system where shared values, collectivism, inclusivity, and a respect for obligations by all segments of society are a reality, and on its negative end by an individualistic, overly hierarchical, short sighted, reactionary, oppressive, and gridlocked governance system. The second axis, "Environment and Economic Balance," was characterized on its positive end by a thriving synergy between economy and environment, and on its negative end by an environment, economy, or both that were in poor shape. The intersection of these axes framed four alternative 50-year projections, characterized by combinations of their positive and/or negative axis end points. These four alternate futures portrayed a basin that was: living on the edge (−/+); thriving and prosperous (+/+); trying hard to adapt (+/−); and out of control (−/−), and reveal policy and strategic research needs and policy recommendations to reach a thriving future.

Introduction

Scenario analysis is a tool to visualize alternative futures and enable us to consider complicated and complex management issues in a novel way. It has been used in many fields, including crisis management, science, policy, education, business, and futurist studies (Bradfield et al., 2005). It is a structured approach that supports strategic thinking. Its ultimate goal is to establish an organization's ability to adapt and "gain the high ground," allowing it to achieve end goals regardless of the environment within which it may find itself (Van der Heijden, 1996). Scenario analysis accomplishes this by integrating factors such as science, technology, politics, economics, and societal information into a decision framework that acknowledges, organizes, and appreciates uncertainty (Wack, 1985a). This decision framework integrates the aforementioned factors in the analysis to generate alternative and internally consistent pathways to futures that describe different worlds, fostering a deeper understanding of risk and the ability to plan for it (Wack, 1985a).

The use of scenario analysis to visualize alternative futures has received tremendous support in initiatives to manage large, complex systems (Swart et al., 2004; Duinker & Greig, 2007). Scenario analysis and the process of envisioning alternate futures provide decision makers the ability to look beyond current understanding, anticipate future changes, and take approaches that are well suited for environmental resource management (Alcamo, 2008; Schweizer & Kriegler, 2012).

Different approaches can be taken when conducting a scenario analysis, including those based on qualitative to quantitative techniques (Bradfield et al., 2005; Huss & Honton, 1987). The Intuitive Logistic Method (ILM) adopts a qualitative approach to conducting scenario analysis that generates alternative and equally plausible futures by

☆ The Great Lakes Futures Project brought together graduate students and expert mentors from universities and institutions in Canada and the United States. Each paper required collaboration between a number of authors with many of them sharing co-leadership that we denote using a †.

* Corresponding author. Tel.: +1 519 661 2111x86843.
E-mail addresses: kiglic2@uwo.ca (K.L. Laurent†), scavia@umich.edu (D. Scavia†), kbf@buffalo.edu (K.B. Friedman), krantz@mcmaster.ca (G.K. Krantzberg), icreed@uwo.ca (I.F. Creed).
[1] Tel.: +1 734 615 4860.
[2] Tel.: +1 716 878 2440.
[3] Tel.: +1 905 525 9140x22153.
[4] Tel.: +1 519 661 2111x86843.

http://dx.doi.org/10.1016/j.jglr.2014.11.006
0380-1330/

creating a space for "remarkable" conversations, identifying and embracing a system's uncertainty, and presenting strategic options for decision making (Bradfield et al., 2005). It involves structured steps that can be customized to any system, which include, but are not limited to, identifying key drivers of change, identifying key uncertainties of a system, developing future scenarios, and identifying strategies to reach a specific future and/or deal with each future should it unfold (Huss & Honton, 1987). In the field of natural resource management, the ILM has the potential to play an integral and supportive role for on-going management initiatives. Research has shown that the ILM can transcend disciplinary boundaries, enable the consideration of uncertainty, create a common language among science-policy-stakeholder groups, be customized to different scales, and be combined with additional approaches that enhance management strategies (Laurent et al., 2015).

An opportunity within the Great Lakes–St. Lawrence River basin

The identification of drivers of change, key uncertainties, alternate and plausible futures, and policy and research strategies is important when managing a complicated natural system such as the Great Lakes–St. Lawrence River basin. Although marked by an impressive history of over 100 years of political initiatives aimed at protecting and restoring specific aspects of the basin (Fig. 1; Jetoo et al., 2015), the system has, and continues to be, bombarded by stressors that threaten the ecosystem as a whole, as well as the ecological services that it provides.

There is growing consensus that the Great Lakes basin is approaching an ecological tipping-point (Cairns, 2004; Marten, 2005), where ecosystem-level changes have the potential to occur quickly and without warning (Bails et al., 2005). Signs that this tipping point is approaching include disruption of food webs through loss of benthic organisms in all of the lakes but Lake Superior, declines in the whitefish population in both Lakes Huron and Michigan, continued eutrophication in Lake Huron's Saginaw Bay and Lake Michigan's Green Bay, the persistence of Lake Erie's anoxic zone, and the elimination of rooted plant communities and benthic food webs simplification due to extensive pollution and sediment loading to bays within Lakes Erie and Ontario (Bails et al., 2005). Each of the lakes is undergoing fundamental ecological changes, and the ecological breakdown of the Great Lakes basin will have serious impacts on its economy, an economy that supported an economic output of $4.7 trillion USD in 2011 (Kavcic, 2013).

The Great Lakes basin urgently needs a novel approach to support current resource management strategies and inform management strategies to overcome barriers to reaching a sustainable future. This approach, as argued by Laurent et al. (2015), is the ILM of scenario analysis. Each phase of the ILM offers important contributions to the natural resource management strategies of basin, such as raising awareness of important drivers and uncertainties for the basin, identifying and overcoming barriers to sustainability, creating effective cross-disciplinary relationships, and training the next generation of political and research leaders (Laurent et al., 2015). Furthermore, this process creates four alternate futures. One of these futures marks a state desired by stakeholders within the basin, providing a vision that can guide policy and planning frameworks as well as provide indicators of moving towards a future that is sustainable.

The Great Lakes Futures Project: an opportunity to embrace uncertainty and explore the future

Concerns that efforts to ensure the sustainability of the basin are failing were the impetus for the Great Lakes Futures Project (GLFP) (Creed & Laurent, 2015). The GLFP conducted an ILM scenario analysis that took signals from the past 50 years (1963–2013) to envision possible future scenarios 50 years into the future (2013–2063). The GLFP brought together academics, graduate students, government, non-government organizations (NGOs), and industry organizations in both Canada and the United States to forge consensus on the desired future of the basin. The GLFP analyzed current policy trajectories for the basin and constructed actionable recommendations to bring public policies closer to achieving socio-ecological sustainability for the basin, characterized by a "thriving" social, ecological, and economic reality (Friedman et al., 2015). The GLFP sought an inter-generational, inter-disciplinary, and cross-sector understanding of the future of the basin to foster long-term strategic policy formulation, program and research priority development and implementation, and training of the next generation of Great Lakes leaders.

The GLFP addressed the following questions: What are plausible futures of the Great Lakes basin in 2063, and what changes do we need to make now to ensure that the basin reaches a collectively desired future? In this paper, we provide an overview of the four steps conducted for the GLFP that were adopted from the ILM approach (Huss & Honton, 1987; Wack, 1985a, 1985b) including: 1) describe key drivers of change; 2) identify critical axes of high-impact/high-uncertain forces; 3) describe scenarios for the futures framed by the two axes; and 4) assess their policy implications. We focus on the activities that took place for the second step, identifying the critical forces defining alternative futures for the Great Lakes basin, which we considered the most challenging step in the scenario analysis.

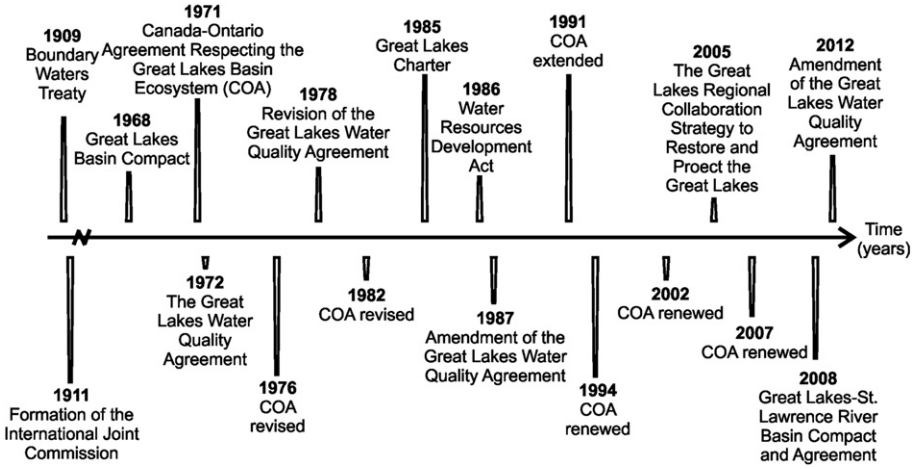

Fig. 1. Time line of political initiatives within the Great Lakes–St. Lawrence River basin (dates based on information from Jetoo et al., 2015).

Methods

Step 1: GLFP boundary conditions and key drivers of change

Great Lakes region researchers were invited to a workshop on March 29–30, 2012 at Western University, in London, Ontario, Canada. Academic researchers were selected to participate in this inaugural workshop due to their experience with the Great Lakes basin. The purpose of this workshop was to formally launch the GFLP, set boundary conditions for the GLFP, and brainstorm drivers of change within the basin. The boundary conditions for the GLFP were discussed in plenary and workshop participants were asked to consider the temporal and spatial scale of the GLFP. Ideas were discussed and consensus achieved through a participant poll.

The drivers of change were brainstormed in small breakout groups during the workshop. Workshop participants were asked to identify and list all drivers of change impacting the Great Lakes basin. The list of drivers was discussed as a group in plenary among all workshop participants and this list informed the final selection of the drivers of change for the GLFP, which was done by the GLFP leadership team. Prior to finalizing the drivers of change, workshop participants were notified of the potential drivers and asked to provide their feedback.

Once the drivers of change were finalized, binational faculty-graduate student research teams were formed to develop papers for each driver. The Great Lakes faculty mentors were selected based on their experience with the Great Lakes basin system and/or the pertinent driver. Graduate students entered a competition to participate and gain experience over and above their relative graduate program commitments at their host institutions. A common structure for the driver papers was adopted that included: an introduction to the driver, a literature review of the driver in the context of the Great Lakes basin (i.e., the influences of the driver on the other GLFP drivers and the influences of the other GLFP drivers on driver); a review of the driver since 1963; and a future projection of the driver 50 years into the future. For consistency, three scenarios were developed for each driver and named: Utopia, Status Quo, and Dystopia.

Step 2: defining the critical forces

Great Lakes region community members were invited to a workshop on January 8–9th 2013 at the University of Michigan, Ann Arbor, Michigan, US to listen to student led presentations on the drivers of change in the basin, and to identify the critical forces operating within the basin. Workshop participants were selected and invited to participate based upon their experience and expertise related to the Great Lakes basin and its policies. Representatives from academia, government, NGOs, and industry organizations participated in different capacities over the course of this two-day workshop.

On the first day, workshop participants included the GLFP leadership, faculty mentors and graduate students. Following a series of presentations of the drivers, workshop participants were divided into breakout groups and completed the axis identification exercise (see below). On the second day, a larger and more diverse group of workshop participants (representing academia, government, industry organizations, NGOs, and graduate students from Canada and the US) provided feedback on the driver papers and participated in facilitated breakout sessions to identify the critical forces.

Our processes for the identification of the critical forces followed the protocol outlined by Maack (2001), based on the Schwartz/Global Business Network approach (Schwartz, 1996) and adapted from Wilson (1998). This protocol was selected because it provided a structured process for ranking the drivers and facilitating the creative and often challenging brainstorming exercise that is required to identify the two critical forces operating within the GLFP. The protocol of Maack (2001) provided a solid foundation for workshop participants to launch into the creative space necessary to identify the critical forces. It facilitated the careful consideration of the interactive effects of multiple drivers operating at multiple time and space scales for the Great Lakes basin that was required.

Workshop participants determined the critical forces by ranking drivers of change in an Impact–Uncertainty Matrix (Table 1) (Maack, 2001; Wilson, 1998). This process involved open dialog to reach consensus on the forces that are certain vs. uncertain (Ogilvy & Schwartz, 2004), and of high vs. low impact (Van der Heijden et al., 2002). Highly uncertain forces in a system are those that are generally both uncontrollable and unpredictable (Peterson et al., 2003), including elements such as market prices, demand for export goods, changes in political values (Maack, 2001), and abrupt climate change (Alley et al., 2003). In contrast, highly certain forces are those that are unlikely to change significantly in the future, or can be predicted with confidence (Ogilvy & Schwartz, 2004; Van der Heijden, 1996). Predictable trends are generally constrained by elements such as time delays (e.g. developments that are "in the pipeline," like demographics), system constraints (e.g. limits to growth), actor logic and motivation (e.g. political party platforms), system inertia (e.g. momentum required for political power shifts), culture (e.g. the basic beliefs and values of a large community), and the laws of nature (e.g. the will to survive) (Van der Heijden, 1996). As cautioned by Ogilvy and Schwartz (2004), these highly certain/predictable forces should be avoided when conducting a scenario analysis under the ILM. The ultimate objective was to select two highly uncertain and high impact forces, or combinations of forces, that generate the two axes to frame the scenario analysis (Schwartz, 1996; Van der Heijden, 1996; Wack, 1985a).

With this guidance in hand, workshop participants categorized the eight drivers selected from step 1 of the GLFP according to their relative uncertainty and impact in Maack's (2001) matrix (Table 1). Workshop participants were encouraged to consider all drivers, those selected in step 1 and other potential drivers, and to consider "meta" drivers (i.e. collapsing related drivers). The consideration of other drivers was important because while the GLFP was forced to constrain the project scope and selected the top eight drivers for assessment, it was clear that other drivers were important. Therefore, encouraging the workshop participants to consider other drivers provided an opportunity for other drivers to be reintroduced to the GLFP and to inform the critical force selection. Each participant placed the drivers or some combination of drivers into the matrix; each driver's weighted occurrence within the matrix guided the discussion and debate around axis selection.

After substantial discussion and debate, each breakout group selected two forces (two axes) from the "highly uncertain/highly relevant" matrix square, described the end point characteristics for each, and defined the futures of each resulting quadrant. The resultant critical force combinations and future scenarios were then discussed in plenary. This plenary session included all workshop participants, and each group presented their final critical force selection.

After each group's critical forces were presented, two combinations (four critical forces/axes in total) were selected based on the major themes presented by the breakout groups. The two critical force combinations (or four critical forces/axes) were discussed and debated further in a second plenary session. Post-debate, a "straw poll" was conduced on the four critical forces/axis options to identify which two critical forces the workshop participants considered most appropriate for the GLFP. These results influenced the final selection of two critical forces for the GLFP, which was done by the GLFP leaders after the workshop.

Step 3: developing the four alternate futures for the Great Lakes–St. Lawrence River basin

Once the critical forces were identified, a second group of binational faculty–graduate student research teams was formed to develop narratives for each future. The Great Lakes faculty mentors were the GLFP leaders and the graduate students were selected from a second competition. Scenario narratives were prepared in the form of "future

Table 1
The Impact vs. Uncertainty Matrix (Maack, 2001) used by participants in the Great Lakes Futures Project workshop to prioritize the eight drivers of change and identify the critical forces.
Source: Maack (2001), adapted from Wilson (1998).

Degree of Importance	Degree of Uncertainty: Low	Medium	High
High	Critical planning issues Highly relevant and fairly predictable (can often be based on existing projections). Should be taken into account in all scenarios.	Important scenario drivers Extremely important and fairly certain. Should be used to differentiate scenarios. Should be based on projections but potential discontinuities also should be investigated.	Critical scenario drivers Factors and forces essential for success and highly unpredictable. Should be used to differentiate scenario plots and trigger exit strategies.
Medium	Important planning issues Relevant and very predictable. Should be figured into most scenarios.	Important planning issues Relevant and somewhat predictable. Should be present in most scenarios.	Important scenario drivers Relevant issues that are highly uncertain. Plausible, significant shifts in these forces should be used to differentiate scenario plots.
Low	Monitorable issues Related to the decision focus but not critical. Should be compared to projections as scenario is implemented.	Monitorable issues Related but not crucial to the decision focus. Should be monitored for unexpected changes.	Issues to monitor and reassess impact Highly unpredictable forces that do not have an immediate impact on the decision focus. Should be closely monitored.

Shaded square indicates key areas of focus.

histories" for each quadrant, where each story was told as a history as if the writer was situated in 2063 and revealed developments that occurred since 2013. The advantage of taking a future-history approach was that it added depth, richness, and imagination to the narratives through the infusion of events, places, people, and commentaries (Duinker, 2008; Lindgren & Bandhold, 2003).

Scenario narratives were founded in the richness of significant qualitative and quantitative information pertaining to the driving forces of change to ensure that the scenarios were credible (Maack, 2001). Each scenario incorporated the historical and future trends for each of the drivers, both independently and in relation to each other, while considering the political and cultural situations of Canada and the US. Including information from each of the eight driver papers, as well as the potential for technological innovation, was critical because these influenced the future state of the basin and framed its story. By incorporating and describing all drivers of change within the scenarios, the complexity that was lost in their reduction to two main critical forces during step 2 was reinstated (Ogilvy & Schwartz, 2004). The potential heterogeneity of responses among the lakes was considered. Furthermore, the potential impacts of current policy frameworks, such as the 2012 Great Lakes Water Quality Agreement, the Canada-Ontario Agreement Respecting the Great Lakes Ecosystem, and the US Great Lakes Restoration Initiative, were considered.

The scenario narratives were presented at a workshop on June 11–12th, 2013 at McMaster University, Hamilton, Ontario, Canada. As in step 2, workshop participants were selected and invited to participate based upon their experience and expertise related to the Great Lakes basin system and its policies, and workshop participants included representatives from academia, government, NGOs, and industry organizations. Workshop participants provided feedback on the plausibility of the scenarios and which scenario was the one the Great Lakes region community should strive to attain. During breakout sessions, workshop participants also identified current and future policies and initiatives that would influence which scenario we would head to, adding depth and plausibility to the scenario narratives. Furthermore, the reality of the future scenario that current policies are leading the basin towards was discussed in plenary, and policy gaps and opportunities were identified that informed the policy principles and recommendations of the GLFP.

Step 4: policy implications

As in steps 2 and 3, Great Lakes region community members, including representatives from academic, government, NGOs, and industry organizations were invited to participate in the GLFP policy forum, held on October 3, 2013 at the State University of New York at Buffalo, Buffalo, New York, US. Workshop participants provided feedback on the policy principles and recommendations that the GLFP leaders identified as critical for moving towards the desired future identified by GLFP (see Friedman et al., 2015). Through active discussion and real-time electronic surveying, workshop participants provided input on principles to guide policies and specific recommendations for future policies, input that directly influenced the final proposed policy recommendations of the GLFP (Friedman et al., 2015).

Results

Boundary conditions and the drivers of change

All workshop participants agreed upon the boundary conditions for the GLFP. The temporal scale was to be a 100-year period (50 years into the past: 1963, and 50 years into the future: 2063). The spatial scale was to be the entire Great Lakes basin, including all 5 of the Laurentian Great Lakes, their watersheds and airsheds.

The key drivers influencing the airshed, watershed, and water bodies of the Great Lakes basin were brainstormed and the final drivers chosen were: the economy (Campbell et al., 2015), energy (Kelly et al., 2015), geopolitics and governance (Jetoo et al., 2015), demographics and societal values (Méthot et al., 2015), water quantity (Maghrebi et al., 2015), climate change (Bartolai et al., 2015), invasive species (Pagnucco et al., 2015), and biological and chemical contaminants (Cornwell et al., 2015).

The critical forces

The candidates for the critical forces that would define the scenario axes suggested by the breakout groups included: 1) the notion of governance, defined as the way a system is governed by both government actors and the desires of broader society, or the notion of "Human Condition," which focused on the characteristics of a specific state in time; and 2) a specific environmental driver (e.g. climate change); the environment as a whole; or environment and economic balance (Table 2). The candidates for the scenario axes included a "human" force variant and an "environmental" force variant, which was interesting and as one participant noted in a breakout group, "if we're going to be orthogonal, then we're going to end up with human systems vs. natural systems. It's almost an orthogonal necessity" (GLFP workshop participant, University of Michigan, January 8–9th, 2013).

The GLFP leaders selected two alternative sets of axes for further discussion: 1) "Human Condition" and "Environment," and 2) "Human Capacity for Change" and "Environment and Economy Balance." Workshop participants showed overwhelming preference for "Human Capacity for Change" over "Human Condition" and a somewhat mixed preference for "Environment" vs. "Environment and Economic Balance."

"Human Capacity for Change" was regarded highly as a critical force because it encompassed governance and the capacity of society to

Table 2
The critical force combinations for the Great Lakes Futures Project resulting from workshop breakout group discussions.

	Axis 1	Axis 2
Day 1	Environment/economy	Governance
	Climate change	Governance/societal values
	Climate change	Governance/societal values
	Environment	Socio-political
	Ecosystem health	Societal values
Day 2	Natural system	Human system and governance
	Ecosystem health	Public policy and sentiment
	Ecosystem dimension	Human capacity for change
	Environment condition	Human condition
	Environment/economy	Governance and societal values

change while "Human Condition" was a static representation of state (i.e. a snapshot in time that does not reflect the potential for communities to adapt to change). However, there was much debate around the other critical force centered on the perceived complexity of the many possible negative end points on the "Environment and Economic Balance" (e.g., positive environment/negative economy, positive economy/negative environment, and negative environment/negative economy). Furthermore, some argued that the economic aspect of the "Environment and Economy Balance" critical force was actually related to "Human Capacity for Change", and for this reason the "Environment and Economic Balance" was not as independent as it could be if it was "Environment" alone. Although consensus was not reached on the second critical force at the workshop, the discussion informed the final selection by the GLFP leaders of the critical forces: the "Human Capacity for Change" and an "Environment and Economic Balance."

The four alternate 50-year future projections

The intersection of these two critical forces provided a framework for four distinct scenarios (Fig. 2). The upper right quadrant, "Thriving And Prosperous: How We Rallied To Confront Collective Challenges" (Comer et al., 2015), is a future where economy and environment are in balance, there is a strong human capacity to mitigate or adapt to any "surprises" that may occur, and the basin thrives. The lower left quadrant, "Out Of Control: How We Failed To Adapt And Suffered The Consequences" (Kalafatis et al., 2015), is a future where economy and environment are out of balance, and there is little human capacity to mitigate or adapt to change, so the basin suffers as there is no will to change human behavior in response to new economic and environmental realities. The upper left quadrant, "Living On The Edge: How We Converted Challenges Into Profitable Opportunities" (Steenberg et al., 2015), is a future where the economy and environment are in balance,

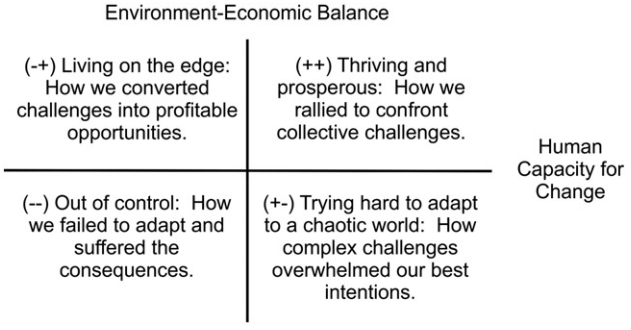

Fig. 2. The alternative future scenarios for the Great Lakes–St. Lawrence River basin as defined by the intersection of the chosen critical forces for the Great Lakes Futures Project.

but there is weak human capacity to mitigate or adapt to any "surprises" that may occur; yet the basin manages. The lower right quadrant, "Trying Hard To Adapt To A Chaotic World: How Complex Challenges Overwhelmed Our Best Intentions" (Orr et al., 2015), is a future where there is a strong will to change human behavior in response to the new economic and environmental realities, but external forces continue to overwhelm the system and the economy and environment are out of balance.

Policy implications

Following the development of the four alternate futures, the GLFP identified gaps to current policies governing the basin and proposed recommendations for bridging these gaps (Friedman et al., 2015).

Discussion

The critical forces for the GLFP

Axis 1: the Human Capacity for Change

The "Human Capacity for Change" axis measures how well human systems can adapt to changing socioeconomic and geopolitical realities. At the positive end of this axis, workshop participants described a human system that exhibits social resilience (Adger, 2000). Social resilience is defined as a community's ability to absorb and recover after a disaster event; the community is committed to survival, has a shared set of values, and is willing to rally around a common cause and adapt (Lamere, 2013). Workshop participants also described a governance system that is proactive, long-sighted, collaborative, adaptive, and a populace that is fully capable of engaging. This governance system is neither top-down nor bottom-up, but rather an effective mix of hierarchical framing and collective decision-making. At the negative end of this axis, workshop participants described a governance system that is overly hierarchical and individualistic (a system dominated by competing values). This governance system is short-sighted, reactionary, oppressive, gridlocked, unable to adjust to changing conditions, and often takes top-down "command and control" approaches. The "Human Capacity for Change" axis created a gradient of social capacity to adapt to and thrive when confronted with change, shaped by the uncertain nature of social, cultural and political values.

The "Human Capacity of Change" axis fulfills the high uncertainty requirement of scenario analysis axes (Schwartz, 1996). "Human Capacity for Change" embodies the notion of "agency" (Brown & Westaway, 2011; McLaughlin & Dietz, 2008), which is the capacity of individuals to make independent choices, enact them, and take collective action (Brown & Westaway, 2011; McLaughlin & Dietz, 2008). By extension, agency is related to a community's ability to adapt and thrive under a changing environment (Brown & Westaway, 2011). Fundamentally, as showcased by Mazur (2013), agency is about power – both individual and collective – and is therefore influenced by what a society values. Its dependency on social values makes agency (and by extension the "Human Capacity for Change") a highly uncertain axis, because changes in values and attitudes can be difficult to predict (Maack, 2001; Van der Heijden, 1996). Therefore, "Human Capacity for Change" was selected as one of the critical forces because it fulfills the criteria of high uncertainty and high impact.

Axis 2: Environment and Economic Balance

The "Environment and Economic Balance" axis measures the alignment of the environment and the economy. At the positive end of this axis, workshop participants described a system where the economy and the environment are balanced and thriving, reflecting the dependence of a healthy economy on a healthy environment. The economic benefits of protection, restoration, remediation and management in the basin (Austin et al., 2007) are a reality and the environment flourishes. At the

negative end of this axis, workshop participants described a system where the environment and the economy are imbalanced. This imbalance can be created either by a strong economy and weak environment, or by a weak economy and strong environment. In this imbalanced state, environmental and economic agendas are often considered independent of each other and, as a result, one suffers as the other benefits. The inter-dependencies of environment and economy increase the uncertainty associated with this axis. Future environmental conditions, like climate change, are considered uncertain and less predictable (Maack, 2001). By combining economy and environment on this axis, its level of uncertainty increases. Although short-term economic forecasts are considered somewhat predictable in the realm of scenario analyses (Maack, 2001), the state of – and more importantly, the trends in – the current global economy is increasingly uncertain (Hirsch, 2013) making longer-term economic projections for the basin fraught with uncertainty. In light of the myriad influences and actors that influence both the economy (GC, 2005) and the environment of the basin (Allan et al., 2013; Bails et al., 2005), their combination creates even greater uncertainty.

Challenges in selecting the critical forces

Interestingly, by selecting an "Environment and Economic Balance" as a critical force for the GLFP, the potential for a balanced, but equally poor environment and economy on the balanced/positive axis end arose, where both could be in a poor state. This was identified in the plenary debate as a potential complication and was an issue that we had to reconcile. To mitigate the potential of a weak environment and weak economy, the weak environment and weak economy condition was explicitly incorporated into the negative end of the axis.

Workshop participants communicated a concern over the relatedness between the economic aspect of the "Environment and Economic Balance" axis and the "Human Capacity for Change" axis. Workshop participants communicated that the economy is a construct of society and, therefore, not independent of the values inherent within the "Human Capacity for Change." However, we were confident with the selection of "Human Capacity for Change" and "Environment and Economic Balance" as the two critical forces for the GLFP because they framed four distinct scenarios (Fig. 2) grounded in archetypes common among global scenario analyses.

MacDonald (2012) examined 64 global scenario stories and found repeating archetypes common to all that include "intent" and "casual" variants. The selection of the "Human Capacity for Change" supports MacDonald's "intent variant" archetype as it generates stories where human and social choices are the main forces of change (i.e., narratives driven by policy goals) (MacDonald, 2012). The selection of the "Environment and Economic Balance" axis supports MacDonald's (2012) "causal variant" scenario narrative archetype because it includes stories where the main forces of change are those which operate with a "natural law," independent of the violation of the human actors. According to MacDonald (2012), "natural law" forces include science, engineering, technology as well as social institutions that are independent of human actions, such as the culture, society and economy. By selecting the "Human Capacity for Change" and "Environment and Economic Balance," the archetypes common to global scenario analyses are accounted for and a strong foundation for future narratives generated.

Although the two critical forces selected for the GLFP aligned with the "archetypes" common to scenario analyses, each also provided a unique perspective to previous scenario analyses on the Great Lakes basin. For instance, in Rankin-Guthro and Krantzberg's (2011) scenario analysis, the Environment and the Economy were selected as the two independent critical forces. In contrast the GLFP combined these two critical forces into one, with an "Environment and Economic Balance" axis. Although it is recognized that both the environment and the economy are uncertain and of high impact, and, as such, are good candidates to serve independently as critical forces in Rankin-Guthro and Krantzberg (2011), the GLFP provided a unique perspective of the two forces and as such eliminated the false dichotomy that can sometimes exist between the environment and the economy (Gardiner & Portney, 1999; Porter & van der Linde, 1995a, 1995b). The GLFP embraced the idea that as we comprehend the reliance of humans on ecological services, the obvious intimate and strong interdependencies between the environment and other factors such as the economy must be considered (Lubchenco, 1998), a viewpoint that supports sound natural resource management.

Four plausible futures for the Great Lakes–St. Lawrence basin

In the future scenario, "Thriving And Prosperous: How We Rallied To Confront Collective Challenges" (Comer et al., 2015), the Great Lakes–St. Lawrence River basin is characterized by high capacity for change and the environment and the economy are in balance. The Great Lakes residents, scientists, and policymakers recognized that current approaches to environmental policy failed to provide environmental, social, and economic prosperity in the long-term. The region's residents agreed on a common set of guiding principles for future policy actions to improve cooperation and collaboration and the policies implemented recognized the basin as a complex social–ecological system and aimed at improving and sustaining human well-being. Overall, the region reaped the benefits of prudent policies. In 2063, the Great Lakes region is a model for how a long-term commitment to environmental improvement can: improve human well-being, improve quality of life, and drive a strong and resilient economy (Comer et al., 2015).

In the "Out Of Control: How We Failed To Adapt And Suffered The Consequences" (Kalafatis et al., 2015) scenario, the Great Lakes basin is characterized by low capacity for change and the environment and economy are not in balance. The challenges facing the basin in 2063 dwarf those it experienced in the early 21st Century. In the year 2063, the Great Lakes basin is challenged by rising international tensions, economic malaise, and accelerating climate change impacts. Leading to this future, the early signs of economic, environmental, and governmental vulnerability were met with neglect. For instance, necessary monitoring and evaluation of environmental protections went unfunded, research and development was unsupported, and regional partnerships fractured with a focus solely on short-term survival. The Great Lakes basin ecosystem was degraded, fossil fuel extraction continued, and the economy benefited from a thorough dependence on these extractive industries. In this future, the Great Lakes themselves have been reduced to objects of trade and the citizenry has lost their once "treasured" opinion of the important resource (Kalafatis et al., 2015).

In the "Living On The Edge: How We Converted Challenges Into Profitable Opportunities" (Steenberg et al., 2015) scenario, the region is characterized by good environmental and economic balance. The basin benefited from and depended upon human choices and natural forces outside the region that pushed and pulled it towards a precarious balance. The region evaded extreme climate-change impacts. The economy of the region emerged as a powerhouse, based on tremendous investment in green energy technology. This economic shift occurred despite the death of cooperative federalism and decades of ideological politics and gutted science-based, citizen-participatory regulatory structures. Governance at local scales was highly variable and the federal government withdrew its activity completely. As such, in this future, the Great Lakes region sits precariously on the "edge" and rides on the coattails of past policies (Steenberg et al., 2015).

In the "Trying Hard To Adapt To A Chaotic World: How Complex Challenges Overwhelmed Our Best Intentions" (Orr et al., 2015) scenario, the Great Lakes region is characterized by high capacity for change and the environment and the economy are not balanced. In this scenario, the Great Lakes basin citizenry is united around a common vision of a healthy Great Lakes region, recognizing and appreciating their direct dependence on them. Although this vision is realized in this future, best efforts to find a balance between human prosperity

and environmental integrity were overwhelmed by climate change, an aging population, geopolitical pressures such as environmental refugees, a sluggish economy, an opposition to environmental degradation of natural resource extraction, impacts of education programs, and widespread effects of both failing social services and physical infrastructure. The inability of best efforts to reach this vision of the Great Lakes region citizenry fostered grassroots mobilization of communities around New England town hall-style meetings. This social movement mobilized and integrated governance based on a common vision and values. Unfortunately, although the residents of the Great Lakes region had tremendous capacity to act, the complex and interrelated forces driving change in the Great Lakes region were unstoppable (Orr et al., 2015).

The process of generating alternative yet plausible futures for the Great Lakes basin created a space to explore the barriers and opportunities of current basin policies. The gaps in current policies that the GLFP identified were: Great Lakes policies are fragmented vertically and horizontally across scale and jurisdiction; Great Lakes policies are fragmented substantively, and lack a holistic approach; policy implementation is hindered by inadequate capacity, accountability, and enforcement; adaptive management remains elusive; there is a collapse of Canadian support for investment in Great Lakes research and education; and the Great Lakes basin lacks a shared vision for the future (Friedman et al., 2015). To bridge these gaps, the GLFP proposed the following policy recommendations: 1) Seek out opportunities to develop 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 innovation and societal well-being; 3) Develop and monitor indicators of comprehensive basin health, strengthen existing and create new Great Lakes region experiential programs; and 4) Develop stakeholder-driven planning and visioning that is legitimized by political leadership both before and after planning occurs to nurture a Great Lakes "citizenship" or "identity" (Friedman et al., 2015).

Conclusion

Scenario analysis is an important tool to explore the complex problems facing the Great Lakes basin. The critical step of selecting the two critical forces affecting the basin that provide the framework for defining the four alternative futures was particularly challenging. There was substantial debate as to which of the drivers influencing the basin were of the highest impact and uncertainty. Informed by this debate, the two critical forces that were selected, "Human Capacity for Change", (intent) and "Environment and Economic Balance," (causal), turned out to have strong theoretical support from the field and practice of scenario analysis. Furthermore, although the critical forces of the GLFP do encompass the social, environmental and economic pillars of sustainability, they reflect a novel perspective in that the economy is intricately linked and dependent on a thriving environment.

Acknowledgments

We thank all of those who participated in the series of workshops that formed the foundation of the Great Lakes Futures Project. We would also like to thank the Graham Environmental Sustainability Institute and the University of Michigan for hosting the workshop held at the University of Michigan at which the critical forces were determined, the funders of the Great Lakes Futures Project, and the Transborder Research University Network. We acknowledge the Canada Research Chair (950-228034) and the Canadian Network for Aquatic Ecosystem Services (417353-2011) grants to Dr. Irena Creed. We also extend our gratitude to two anonymous reviewers for the paper.

References

Adger, W.N., 2000. Social and ecological resilience: are they related? Prog. Hum. Geogr. 24, 347–363.
Alcamo, J., 2008. Introduction: the case for scenarios of the environment. In: Alcamo, J. (Ed.), Environmental Futures: The Practice of Environmental Scenario Analysis. Elsevier B.V., Amsterdam, pp. 1–12.
Allan, J.D., McIntyre, P.B., Smith, S.D.P., Halpern, B.S., Boyer, G.L., Buschbaum, A., Burton, G.A., Campbell, L.M., Chadderton, W.L., Ciborowski, J.J.H., Doran, P.J., Eder, T., Infante, D.M., Johnson, L.B., Joseph, C.A., Marino, A.L., Prusevich, A., Read, J.G., Rose, J.B., Rutherford, E.S., Sowa, S.P., Steinman, A.D., 2013. Joint analysis of stressor and ecosystem services to enhance restoration effectiveness. Proc. Natl. Acad. Sci. 10 (1), 372–377.
Alley, R.B., Marotzke, J., Nordhaus, W.D., Overpeck, J.T., Peteet, D.M., Pielke, R.A., Pierrehumbert, R.T., Rhines, P.B., Stocker, T.F., Talley, L.D., Wallace, J.M., 2003. Abrupt climate change. Science 299, 2005–2010.
Austin, J.C., Anderson, S., Courant, P.N., Litan, R.E., 2007. Healthy Waters: Strong Economy: The Benefits of Restoring the Great Lakes Ecosystem. The Brookings Institution, Washington, DC.
Bails, J., Beeton, A., Bulkley, J., DePhilip, M., Gannon, J., Murray, M., Regier, H., Scavia, D., 2005. Prescription for Great Lakes: ecosystem protection and restoration avoiding the tipping point of irreversible changes. Healing Our Waters-Great Lakes Coalition Technical Advisory Committee December 2005, (39 pp., Accessed online 10-20-2014 at: http://healthylakes.org/publications/#sthash.EGSUPa3T.dpuf).
Bartolai, A., He, L., Hurst, A., Mortsch, L., Paehlke, R., Scavia, D., 2015. Climate change as a driver of change in the Great Lakes St. Lawrence River basin. J. Great Lakes Res. 41 (Supplement 1), 45–58.
Bradfield, R., Wright, G., Burt, G., Cairns, G., Van Der Heijden, K., 2005. The origins and evolution of scenario techniques in long range business planning. Futures 37, 795–812.
Brown, K., Westaway, E., 2011. Agency, capacity, and resilience to environmental change: lessons from human development, well-being and disasters. Annu. Rev. Environ. Resour. 36, 321–342.
Cairns Jr., J., 2004. Ecological tipping points: a major challenge for experimental sciences. Asian J. Exp. Sci. 18, 1–16.
Campbell, M., Cooper, M., Friedman, K.B., Anderson, W., 2015. The economy as a driver of change in the Great Lakes–St. Lawrence River basin. J. Great Lakes Res. 41 (Supplement 1), 69–83.
Comer, B., Fera, S., Splawinski, S., Laurent, K.L., Friedman, K.B., Krantzberg, G., Scavia, D., Creed, I.F., 2015. Thriving and prosperous: how we rallied to confront collective challenges. J. Great Lakes Res. 41 (Supplement 1), 161–170.
Cornwell, E.R., Goyette, J.-O., Sorichetti, R.J., Allan, J.D., Kashian, D.R., Sibley, P.K., Taylor, W.D., Trick, C.G., 2015. Biological and chemical contaminants as drivers of change in the Great Lakes St. Lawrence River basin. J. Great Lakes Res. 41 (Supplement 1), 119–130.
Creed, I.F., Laurent, K.L., 2015. The Great Lakes Futures Project. J. Great Lakes Res. 41 (Supplement 1), 1–7.
Duinker, P.N., 2008. Scenarios of the forest futures project: why and how we created them, and how to use them. Sustainable Forest Management Network.
Duinker, P.N., Greig, L.A., 2007. Scenario analysis in environmental impact assessment: improving explorations of the future. Environ. Impact Assess. 27, 206–219.
Friedman, K.B., Laurent, K.L., Krantzberg, G., Scavia, D., Creed, I.F., 2015. The Great Lakes Futures Project: principles and policy recommendations for making the lakes great. J. Great Lakes Res. 41 (Supplement 1), 171–179.
Gardiner, D., Portney, P.R., 1999. Does environmental policy conflict with economic growth? In: Oates, W.E. (Ed.), The RFF Reader in Environmental and Resource Management. RFF Press, pp. 21–26.
Government of Canada (GC), 2005. Policy Research Initiative 2005. Canada–US Relations and the Emergence of Cross-Border Regions.
Hirsch, T., 2013. Growing uncertainty clouding economists' crystal balls. The Globe and Mail, (Accessed online 10-20-2014 at: http://www.theglobeandmail.com/report-on-business/economy/economy-lab/growing-uncertainty-clouding-economists-crystal-balls/article14001789/).
Huss, W.R., Honton, E.J., 1987. Scenario planning — what style should you use? Long Range Plan. 20, 21–29.
Jetoo, S., Thorn, A., Friedman, K.B., Gosman, S., Krantzberg, G., 2015. Governance and geopolitics as a driver of change in the Great Lakes St. Lawrence River Basin. J. Great Lakes Res. 41 (Supplement 1), 108–118.
Kalafatis, S., Campbell, M., Fathers, F., Laurent, K.L., Friedman, K.B., Krantzberg, G., Scavia, D., Creed, I.F., 2015. Out of control: how we failed to adapt and suffered the consequences. J. Great Lakes Res. 41 (Supplement 1), 20–29.
Kavcic, R., 2013. Great Lakes Region: North America's Economic Engine. Bank of Montreal, (Accessed online 03-10-2014 at: http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCwQFjAA&url=http%3A%2F%2Fwww.bmonesbittburns.com%2Feconomics%2Freports%2F20130531%2FGreatLakes1305.pdf&ei=FHUgU5SjFOfp2QW2uoCgCg&usg=AFQjCNE8VoLQZndtgActdCfXRuLgJ1ALw&sig2=U3-5uClyMk3OUo4izPb0JA&bvm=bv.62788935,d.b2I&cad=rja).
Kelly, B., Keeler, B., Helm, G., Krantzberg, G., Lyon, T., Friedman, K., Mabee, W., 2015. Energy as a driver of change in the Great Lakes–St. Lawrence River basin. J. Great Lakes Res. 41 (Supplement 1), 59–68.
Lamere, C., 2013. Bouncing Back: How Do Population Dynamics and Social Cohesion Affect the Resilience of Societies? Wilson Center/Toward Resilience, (Accessed online 10-20-2014 at: http://www.newsecuritybeat.org/2013/04/bouncing-back-population-dynamics-social-cohesion-affect-resilience-societies/#.UiY5vIWTPSE).

Laurent, K.L., Friedman, K.B., Krantzberg, G., Scavia, D., Creed, I.F., 2015. Scenario analysis: an integrative and effective method for bridging disciplines and achieving a thriving Great Lakes–St. Lawrence River basin. J. Great Lakes Res. 41 (Supplement 1), 12–19.

Lindgren, M., Bandhold, H., 2003. Scenario Planning, the Link Between Future and Strategy. Palgrave Macmillan, New York, NY.

Lubchenco, J., 1998. Entering the century of the environment: a new social contract for science. Science 279, 491–497.

Maack, J.N., 2001. Scenario analysis: a tool for task managers. Social Development Paper 36. Social Analysis: Selected Tools and Techniques, pp. 62–87 (Washington, Accessed online 07-08-2013 at: http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CDEQFjAA&url=http%3A%2F%2Fsiteresources.worldbank.org%2FEXTSOCIALDEV%2FResources%2F3177394-1167940794463%2FScenarioAnalysisMaack.pdf&ei=eOPaUe_lO8v2iQKDzoD4Ag&usg=AFQjCNFS_HzMGG-Lr1mLJ54L0UPwLWE5zA&sig2=qBhcsL6dC-hLYSjOXqYALA&bvm=bv.48705608,d.cGE).

MacDonald, N., 2012. Futures and culture. Futures 44, 277–291.

Maghrebi, M., Nalley, D., Laurent, K.L., Atkinson, J., 2015. Water quantity as a driver of change for the Great Lakes–St. Lawrence River basin. J. Great Lakes Res. 41 (Supplement 1), 84–95.

Marten, G.G., 2005. Environmental tipping points: a new paradigm for restoring ecological security. J. Policy Stud. 20, 75–87.

Mazur, L., 2013. Goldilocks Had It Right: How to Build Resilient Societies in the 21st Century. Toward Resilience: Wilson Center, (Accessed online 10-20-2014 at: http://www.newsecuritybeat.org/2013/03/goldilocks-right-build-resilient-societies-21st-century/#.UiY52IWTPSE).

McLaughlin, P., Dietz, T., 2008. Structure, agency and environment: toward an integrated perspective on vulnerability. Glob. Environ. Chang. 18, 99–111.

Méthot, J., Huang, X., Grover, H., 2015. Demographics and societal values as a driver of change for the Great Lakes–St. Lawrence River basin. J. Great Lakes Res. 41 (Supplement 1), 30–34.

Ogilvy, J., Schwartz, P., 2004. Plotting Your Scenarios. Global Business Network, Berkeley, CA.

Orr, C., Williams, K., Laurent, K.L., Friedman, K.B., Krantzberg, G., Scavia, D., Creed, I.F., 2015. Trying hard to adapt to a chaotic world: how complex challenges overwhelmed our best intentions. J. Great Lakes Res. 41 (Supplement 1), 139–149.

Pagnucco, K., Maynard, G., Fera, S., Yan, N., Nalepa, T., Ricciardi, A., 2015. The future of species invasions in the Great Lakes-St. Lawrence River basin. J. Great Lakes Res. 41 (Supplement 1), 96–107.

Peterson, G.D., Cumming, G.S., Carpenter, S.R., 2003. Scenario planning: a tool for conservation in an uncertain world. Conserv. Biol. 17, 358–366.

Porter, M.E., van der Linde, C., 1995a. Toward a new conception of the environment-competitiveness relationship. J. Econ. Perspect. 9, 97–118.

Porter, M.E., van der Linde, C., 1995b. Greening and competitive: ending the stalemate. Harv. Bus. Rev. 119–134 Reprint. 95507.

Rankin-Guthro, E.E., Krantzberg, G., 2011. The Lorax can win: using scenario building to create a new vision and invigorate an "activist" agenda for the Great Lakes St. Lawrence basin. Electron. Green J. 1, 1–22.

Schwartz, P., 1996. The Art of the Long View. Bantam Doubleday Dell Publishing Group, Inc., New York, NY.

Schweizer, V.J., Kriegler, E., 2012. Improving environmental change research with systematic techniques for qualitative scenarios. Environ. Res. Lett. 7, 1–14.

Steenberg, J., Timm, M., Laurent, K.L., Friedman, K.B., Krantzberg, G., Scavia, D., Creed, I.F., 2015. Living on the edge: how we converted challenges into profitable opportunities. J. Great Lakes Res. 41 (Supplement 1), 150–160.

Swart, R.J., Raskin, P., Robinson, J., 2004. The problem of the future: sustainability science and scenario analysis. Global Environ. Chang. 14, 137–146.

Van der Heijden, K., 1996. Scenarios: The Art of Strategic Conversation. John Wiley, Chichester, UK.

Van der Heijden, K., Bradfield, R., Burt, G., Cairns, G., Wright, G., 2002. The Sixth Sense: Accelerating Organization Learning with Scenarios. Wiley, Chichester, UK.

Wack, P., 1985a. Scenarios: shooting the rapids. Harv. Bus. Rev. 85617.

Wack, P., 1985b. Scenarios: uncharted waters ahead. Harv. Bus. Rev. 85516.

Wilson, I., 1998. Mental maps of the future: an intuitive logics approach to scenarios. In: Fahey, L., Randall, R.M. (Eds.), Learning from the Future: Competitive Foresight. John Wiley & Sons, Inc., pp. 81–108.