"Make No Little Plans": Developing Biodiversity Conservation Strategies for the Great Lakes

Douglas R. Pearsall, Mary L. Khoury, John Paskus, Dan Kraus, Patrick J. Doran, Scott P. Sowa, Rachael Franks Taylor, Lauri K. Elbing

The Laurentian Great Lakes represent the world's largest freshwater ecosystem and contain irreplaceable biodiversity. Lakewide Action and Management Plans (LAMPs) hold the highest potential for ecosystem management in the Great Lakes but have not specifically addressed biodiversity status or strategies for conservation. For four Great Lakes, recently completed biodiversity conservation strategies (blueprints) have assessed the status and threats to biodiversity and recommended strategies for conservation and restoration; a blueprint is under way also for Lake Superior. Here, we compare the completed blueprints and explore challenges to conservation planning for large ecosystems. We also assess whether earlier blueprints are being adopted and offer suggestions for more effective implementation. All of the blueprints focus on biodiversity in the lakes and coastal areas, and some include tributaries and migratory species. Biodiversity status was rated as fair (out of desirable range but restorable) in each lake, with some exceptions and considerable spatial variability. Aquatic invasive species ranked as a top threat to biodiversity in all four blueprints. Other highly ranked threats included incompatible development, climate change, terrestrial invasive species, dams and barriers, and non-point-source pollutants. The recommended strategies are characterized by six themes: coastal conservation, invasive species, connectivity and hydrology, fish restoration, nearshore water quality, and climate change. Each blueprint highlights high-priority strategies, but successful protection and restoration of Great Lakes biodiversity require revisiting these priorities in an adaptive approach.

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The Laurentian Great Lakes and their connecting channels represent the world's largest surface freshwater ecosystem [Government of Canada and United States (US) Environmental Protection Agency, 1995], and, though relatively young geologically, contain irreplaceable biological diversity. Heavy use over the past three centuries has produced significant changes. The presence of once-ubiquitous native fish, including the lake sturgeon and lake trout, has been drastically reduced or virtually eliminated in most regions. Extensive areas of shoreline have been converted, destroying thousands of hectares of wetlands and other coastal ecosystems. Industrial, urban, and agricultural pollution and over 180 nonnative species have led to the replacement of key native species and arguably a permanent alteration of the food web. Yet, the Great Lakes retain many globally important biological features—including the world's largest system of freshwater dunes, endemic coastal plants and animals, and deep-water fish—and will undoubtedly remain as a large-scale "stage" (sensu Anderson and Ferree, 2010) on which nature will continue to thrive and evolve.

The need for collaborative goal setting and strategy implementation in the Great Lakes is tremendous given chal-

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lenges such as vast geographies, complex ecological systems, fragmentation of resources, agency specialization, and multiple, sometimes overlapping, jurisdictions. While there are many regional initiatives intended to promote such collaboration, such as the Great Lakes Restoration Initiative (GLRI) that is directing hundreds of millions of dollars toward Great Lakes restoration, as well as the biannual State of the Lakes Conference (SOLEC) that provides lakewide indicators of ecosystem health, the Lakewide Action and Management Plans (LAMPs) hold the greatest potential for ecosystem management because they bring together stakeholders at regular intervals to coordinate action and will continue to do so into the future. Under the 1987 protocol amending the binational Great Lakes Water Quality Agreement (Government of the US and Government of Canada, 1987), LAMPs were required for each lake, with updates every five years. The LAMPs have set goals and objectives for water quality, human use and enjoyment, and, to varying degrees, ecosystem health as expressed in physical, chemical, and biological terms.

Although the LAMPs are the primary forum by which collaborative, lakewide goals, objectives, and action planning can be developed for most management concerns, excepting fisheries management, which is overseen by the Great Lakes Fishery Commission, they have not previously assessed biodiversity status nor identified strategies needed for conservation and restoration. Both the US Environmental Protection Agency (USEPA) and Environment Canada (EC) recognized the potential for the LAMPs to facilitate Great Lakes biodiversity conservation and, starting in 2007 with Lake Ontario, have invested in the development of biodiversity conservation strategies, colloquially known as *blueprints* for each Great Lake. Blueprints are now complete for four of the Great Lakes: Lake Ontario (Lake Ontario Biodiversity Strategy Working Group, 2009), Lake Huron (Franks Taylor et al., 2010), and Lakes Erie and Michigan (Pearsall et al., 2012a,b, respectively). A biodiversity assessment is also under way for Lake Superior, with strategies to be formulated later by the Lake Superior LAMP (Lake Superior LAMP–Superior Work Group, 2013).

These blueprints have defined multiagency visions for biodiversity conservation, developed shared strategies to protect and restore the lakes, described how these strategies can benefit people, generated baseline information on species and habitats, and are promoting coordinated conservation action. They are intended to provide government agencies, conservation groups, and local communities with a common understanding of priority strategies and to direct actions to the most urgent and important issues facing biodiversity in the Great Lakes. The blueprints also support several of the annexes of the 2012 Great Lakes Water Quality Agreement (Government of the US and Government of Canada, 2012), including establishing baseline and assessment information that will inform future monitoring and ecosystem objectives, identifying areas of high ecological value and the development of lakewide habitat and species protection and restoration conservation strategies.

Here we review and compare the four blueprints in terms of the planning approach and the recommended strategies, specifically how each defines and evaluates biodiversity, assesses threats to biodiversity, develops strategies, and identifies spatial priorities for conservation action. We provide recommendations based on these plans to address the challenges associated with conservation planning for such large and complex—both ecologically and culturally—ecosystems. Finally, we offer suggestions for more effective application of these blueprints toward advancing strategic conservation of biodiversity across the Great Lakes.

Conservation Planning for Great Lakes

Conservation planning treated broadly can be thought of as comprising two main components: systematic conservation assessment (identifying priority areas for taking conservation action) and development of implementation strategies (Knight, Cowling, and Campbell, 2006). There have been several efforts to identify priority areas for conservation in the Great Lakes, including those by Rodriguez and Reid (2001) and The Nature Conservancy (TNC) and Nature Conservancy of Canada (NCC) (2006), the latter of which builds upon and summarizes previous work by TNC (2000) and NCC (Henson, Brodribb, and Riley, 2005; Wichert et al., 2005). Developing implementation strategies produces alignment of goals and specifies actions, leading ultimately to clear responsibilities and accountabilities. The conservation blueprints have achieved alignment of goals and needed actions for four of the five Great Lakes, and provide the basis for coordinating responsibilities and accountabilities as conservation actions proceed.

To develop implementation strategies, each blueprint followed the conservation action planning (CAP) (TNC, 2007) process. A basis for the Open Standards for the Practice of Conservation (Conservation Measures Partnership, 2013), CAP is a proven technique for planning, implementing, and measuring success for conservation projects. Based on an adaptive approach to conservation management, the CAP process helps practitioners focus their conservation strategies on clearly defined elements of biodiversity (or conservation targets) and threats to these targets. The process further leads to creating measures for implementation success in a manner that will enable practitioners to adapt and learn over time (TNC, 2007). CAP includes four steps and 14 basic practices in an adaptive management cycle (Figure 1):

1. Defining the project, including participants, geographic, scope and focal conservation targets

2. Developing conservation strategies and measures, including assessing the viability of focal conservation targets, identifying critical threats, and developing strategies and establishing measures

3. Implementing conservation strategies and measures, which includes developing work plans, taking action, and measuring results

4. Using the results to adapt and improve future strategies

The Great Lakes blueprints focused on the first two steps of CAP. The planning processes also enabled us to establish a foundation for the last two steps (implementation and adaptation) by working closely with the respective LAMPs. Blueprint project teams have promoted adoption of the recommended strategies as LAMP priorities and incorporation into ongoing and nascent projects.

Figure 1. The conservation action planning (CAP) process, an adaptive project management cycle of four steps and fourteen basic practices (The Nature Conservancy, 2007).

Step 1: Defining the Project

Engaging stakeholders

Planning for each lake necessitated inviting the participation of hundreds of stakeholders, including nongovernmental organizations (NGOs); natural resource agencies at the federal, state, provincial, and tribal levels; local and regional government entities; and universities. Many and diverse stakeholders are already engaged in the management and conservation of each of the Great Lakes. Stakeholders for each blueprint represent multiple geopolitical jurisdictions and are broadly distributed geographically. All of the blueprints involved multiple states and, except for Lake Michigan, each was binational.

To manage the challenges associated with serving such a broad set of participants in the planning process (e.g., cost, conflicting schedules, travel restrictions), each project team established a steering committee of roughly 15–50 members (reflecting the varying number of state agencies involved) representing key stakeholders who provided regular input to the process, enabling less frequent outreach to the full set of participants. The Lake Ontario and Lake Huron project teams conducted multiple workshops complimented by webinars for steering committee and technical work groups between workshops. The Lake Michigan and Lake Erie blueprint project teams built on the work on the previous two lakes to define targets and assess viability and critical threats. These teams also held monthly steering committee calls and convened multiple webinars to complete the initial planning steps, and held only one workshop, which focused on strategy development. Project teams, especially for the Lake Erie and Lake Michigan blueprints, also relied on conference calls and webinars. All of the projects developed websites for sharing draft maps and reports with participants.

Biodiversity conservation targets

All of the blueprints were similar in project scope, focusing on the biodiversity in the lakes and coastal areas while including the entire lake basin to account for watershed influences on biodiversity. The blueprints defined a mostly consistent set of seven or eight conservation targets (Table 1). All of the blueprints address nearshore and open-water systems, which are aquatic systems that are demarcated at a depth—the specific depth varies among the lakes—of transition in temperature, dissolved oxygen concentration, and processes that influence the composition and structure of their benthic and pelagic communities. Coastal wetlands and native migratory fish were also recognized as conser-

Table 1. Definitions and viability status ranks for conservation targets in four Great Lakes biodiversity conservation strategies[a]

Target	Lake Ontario	Lake Huron	Lake Erie	Lake Michigan	Average viability
Open-water benthic and pelagic system (Lakes Huron, Erie, and Michigan) Benthic and pelagic offshore systems (Lake Ontario)	The bottom and open waters of the lake in permanently cold water greater than 20 m in depth	Open-water ecosystem beyond the 30-m bathymetric contour from the mainland or islands, including reefs and shoals	Open-water ecosystem beyond the 15-m bathymetric contour from the mainland or islands, including reefs and shoals	Open-water ecosystem beyond the 30-m bathymetric contour from the mainland or islands, including reefs and shoals	Fair
	Fair	Fair	Fair	Fair	
Nearshore zone	Open waters of the lake from the 20-m depth contour to the mean high-water mark along the coast	Submerged lands and water column of Lake Huron starting at 0 m (shoreline) and extending to 30 m in depth	Submerged lands and water column of Lake Erie starting at 0 m (shoreline) and extending to 15 m in depth	Submerged lands and water column of Lake Michigan starting at 0 m (shoreline) and extending to 30 m in depth	Fair
	Fair	Fair	Fair	Fair	
Native migratory fish	Native fish that depend on migration to satisfy their life cycle	Native fish that migrate to and depend on tributaries, nearshore areas, or wetlands as part of their natural life cycle	Native fish that migrate to and depend on tributaries as part of their natural life cycle		Fair
	Fair	Fair	Fair	Fair	
Islands	Both natural and artificial islands	Land masses that are surrounded by water, including both naturally formed and artificial islands that are “naturalized” or support nested targets			Good
	Good	Good	Fair	Good	
Coastal wetlands	Wetlands that have, or historically had, a hydrologic link to Lake Ontario and the Upper St. Lawrence River	All types of hydrogeomorphic wetlands (lacustrine, riverine, barrier protected, plus subcategories including estuaries and island coastal wetlands) with historic and current hydrologic connectivity to, and directly influenced by, Lake Huron/Erie/Michigan			Fair
	Fair	Fair	Fair	Good	

(continued)

Table 1. Continued

Target	Lake Ontario	Lake Huron	Lake Erie	Lake Michigan	Average viability
Aerial migrants	NA	Migrants that have high fidelity to Lake Huron and for which migratory corridors associated with the lake are crucial to their survival	Birds (landbirds, waterfowl, shorebirds, waterbirds) that use open waters of Lake Erie/Michigan and adjacent shorelines, including connecting waters, during spring and fall migration		Fair
	NA	Fair	Good	Fair	
Coastal terrestrial systems	Natural cover from the line of wave action to 2 km inland	Shoreline up to 2 km inland or to the extent of the delineated Great Lakes coastal communities	Upland and wetland natural communities extending from the shoreline up to 2 km inland or to the extent of the (delineated) Great Lake coastal communities		Fair
	Fair	Fair	Fair	Fair	
Rivers, estuaries, and connecting channels	Tributaries to the lake and their associated riparian zones and estuaries	NA	Waterways that connect Lake Erie with adjacent Great Lakes, including the St. Clair River, Lake St. Clair, the Detroit River, and the Upper Niagara River above Niagara Falls	NA	Fair
	Fair	NA	Fair	NA	
Overall biodiversity viability rank	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**

[a] Ratings are given by *color*: orange = fair; green = good (on a scale of poor, fair, good, and very good). Merged cells indicate identical target definitions. NA, not addressed.

vation targets in all the blueprints, as were islands and coastal terrestrial systems. The latter target represents the suite of ecosystems in the coastal area, within 2 km of the shoreline in the coastal area. Aerial migrants, including birds, bats, and invertebrates, were a target in all blueprints except that for Lake Ontario. The Lake Ontario blueprint was the only one to consider tributaries as a separate target, and, with the Lake Erie blueprint, was one of two to name connecting channels (e.g., the Upper and Lower Niagara River, St. Clair River, and Detroit River) as a target. The Lake Huron blueprint incorporated the only other connecting channel—the St. Marys River—as part of the nearshore zone target.

Table 2. Definitions for viability ratings (TNC, 2007)

Status rating	Definition
Poor	Restoration increasingly difficult; may result in extirpation of target
Fair	Outside acceptable range of variation; requires human intervention
Good	Indicator within acceptable range of variation; some intervention required for maintenance
Very good	Ecologically desirable status; requires little intervention for maintenance

Addressing regional heterogeneity

Assessing information and planning at broad scales, such as an entire Great Lake basin, can present challenges for developing, implementing, and tracking a set of strategies. Each Great Lake has considerable regional variation in geology, climate, ecology, economics, governance, human communities, and dominant land use. The approaches used to address this variation within each lake and along the coastal zone evolved from the earliest to most recent blueprint projects. For the Lake Ontario project, the lake was not stratified geographically for assessments of target viability and threats to biodiversity. For Lake Huron, these assessments were stratified differently across targets, depending on the amount of information available for each. For Lakes Michigan and Erie, the lakes were stratified into geographic units at two scales: reporting units or basins that reflect broad patterns of circulation and bathymetry (five for Lake Michigan and four for Lake Erie), and within reporting units, offshore and coastal-nearshore assessment units (17 for Lake Michigan and 13 for Lake Erie). These assessment units were the basic units of analyses of viability of and threats to conservation targets and helped inform development of strategies. For all blueprints, coastal units or watersheds—or both—were also used to report on the biological significance and condition of several targets (see the Identifying Priority Areas section).

Step 2: Developing Biodiversity Conservation Strategies and Measures

Assessing the viability of biodiversity conservation targets

Assessing viability entails evaluating the current "health" and desired future status of each conservation target. The blueprints were consistent in their approach to this assessment, with some variation in spatial resolution. Project teams first identified key ecological attributes and indicators for each conservation target. A *key ecological attribute* (KEA) is an aspect of a target's biology or ecology that, if present, defines a healthy target and, if missing or altered, would lead to the outright loss or extreme degradation of that target over time. Indicators are specific measures to keep track of the status of a KEA. Once the KEAs and indicators have been established, the next task is to assess the current status and set the desired status of the indicators and assign each to categories of *poor*, *fair*, *good*, and *very good* based on the best understanding of the relationship of the indicator to the condition of the conservation target. Project teams incorporate the best available information from literature and expert opinion on each conservation target's biology and ecology to complete this assessment.

At the scale of an entire Great Lake, the current overall viability status of almost all of the conservation targets was rated as fair, the only exceptions being islands in Lakes Ontario, Huron, and Michigan, coastal wetlands in Lake Michigan, and aerial migrants in Lake Erie, all of which were rated as good (Table 1; see Table 2 for definitions of viability ratings). Consequently, the viability status of each lake, in its entirety, is also rated as fair. This pattern reflects that whole-lake viability is calculated as an average of all the indicator values and that there are large numbers of indicators for each target.

Comparison of threat assessments

The blueprints employed two different approaches to assess threats to biodiversity. In brief, a threat assessment involves first identifying the factors that degrade biodiversity conservation targets and then ranking them in order to focus conservation actions where they are most needed. The ranking process entails rating threats in terms of their scope, severity, and irreversibility. Using a rule-based system, these ratings are combined to calculate the overall target–threat rating. The direct threats that are highest ranked are considered the critical threats (Conservation Measures Partnership, 2013).

The Lake Ontario and Lake Huron project teams identified and ranked threats during expert workshops, with one group of experts for each conservation target. They ranked threats at a whole-lake scale. In contrast, the Lake Michigan and Lake Erie blueprints developed an initial list of threats by drawing from existing plans (including previous blueprints) and seeking further input from their project steering committees. Then, they conducted online surveys of experts to rate the scope, severity, and irreversibility of each threat in each of the reporting units (major geographic subunits) in each lake. Finally, the teams combined individual ratings by using a weighted averaging process to obtain a final ranked list of threats.

Among the four blueprints, there are patterns in the threats to conservation targets. Aquatic invasive species (AIS) ranked among the top two threats in each of the blueprints and has the highest average rank across all lakes (Table 3). Incompatible development and climate change also ranked in the top five in each of the blueprints, and terrestrial invasive species, dams and other barriers, and non-point-source pollutants all were consistently ranked high. The blueprints were not the first efforts to identify these threats but were the first to connect these threats clearly and directly to specific conservation targets and provide additional spatial resolution, thereby establishing a framework for linking actions to threat abatement and ultimately to improved viability of conservation targets. Finally, these threat assessments are in general agreement with other basinwide assessments (see Allan et al., 2013).

Conservation strategies:[1] Consistent themes

The purpose of strategy development was to identify what action is most needed to restore or conserve the biodiversity of each Great Lake. In addition, the participants in each planning process wanted to identify the most important places to deploy these strategies. CAP and the Open Standards are intended to help planners identify what needs to be done and the logic for each strategy. To identify where to take action, planning teams for all four lakes complimented CAP with priority-area identification based on biological significance and condition. The methods were consistent among the four blueprints, with some variation due mainly to the evolution of tools to aid in articulating strategies.

Technical workshops provided the primary means to select and develop detailed strategies. Guided by the ranking of critical threats and recommendations for restoration, each project team selected the types of strategies to develop. At the workshops, we divided participants into breakout sessions with 5–15 members to engage in two main steps: first to brainstorm possible strategies, and second to specify necessary actions and measurable objectives for the strategies identified as potentially most effective.

To document the conceptual basis for strategies as they emerged, all project teams used Miradi software (Conservation Measures Partnership, 2013) that enables users to

Table 3. Threat ratings (colors) and ranks (numbers) within each lake for each of the four completed biodiversity conservation strategies[a]

Threat	Lake Ontario	Lake Huron	Lake Erie	Lake Michigan	Average rank
Aquatic invasive species	2	1	1	1	1.25
Incompatible development	1	2	5	3	2.75
Climate change	4	3	2	4	3.25
Terrestrial invasive species	8	4	3	2	4.25
Dams and other barriers	3	5	8	5	5.25
Non-point-source pollutants	5	6	4	7	5.50

[a] Each threat is scored qualitatively based on severity and scope of impact. These scores are combined into an overall threat rating of very high, high, medium, or low. Ratings are indicated by *color*: red = very high; orange = high; green = medium. The relative rank of each threat within one lake is indicated by the *number value*. Note: This list includes only those threats ranked in the top five in any one of the blueprints. Also, threat names were not consistent, so the names presented are representative of the top threats in all blueprints.

identify indirect factors influencing the selected threat or restoration need. For each critical threat, we constructed conceptual diagrams of the current situation, which then provoked discussion of potential strategies. In some cases, as many as 20 strategies were proposed by the experts. As recommended by the Open Standards (Conservation Measures Partnership, 2013), project teams ranked potential strategies based on feasibility and likely impact, allowing only priority strategies to be featured in the plans.

In all cases, we recognized that past studies and plans contain relevant strategies and recommendations. Each plan refers to previous studies and to other plans, and, in some cases, adopts and updates strategies from these sources, responding to changes in conditions, such as new invasive species.

The second step in strategy development involved developing a theory of change or logic statement for how each selected strategy will lead to the desired outcome. The Open Standards provide guidelines for developing a results chain that enables strategy authors to document their desired interim results and assumptions in terms of how one result will facilitate the next. The Lake Huron, Lake Michigan, and Lake Erie plans provide these diagrams, as well as interim objectives and ultimate objectives, for each strategy.

The strategies for the four blueprints cover six themes: coastal conservation, invasive species, connectivity and hydrology, fish restoration, nearshore water quality, and climate change. Each theme was addressed by two or more blueprints (see Table 4). With respect to traditional land protection, the Lake Ontario and Lake Huron plans explicitly list protection strategies for coastal features, whereas the Lake Michigan and Lake Erie plans address protection indirectly through the identification of priority areas for conservation. In the latter two blueprints, direct land protection strategies did not emerge during the strategy development workshops, possibly because of the focus on broader issues. Next, we highlight key similarities and differences within each theme.

Coastal conservation. All four blueprints include strategies intended to improve the effectiveness of land use planning to address conservation in the coastal zone—although the means were diverse, including increasing coordination, building local capacity, increasing community engagement, and building a business case for conservation.

Invasive species. A common emphasis in all the blueprints is the need for coordination, particularly of early-detection and rapid-response actions. The Lake Ontario and Lake Huron blueprints present a comprehensive set of strategies for management of aquatic invasive species. The Lake Michigan and Lake Erie breakout groups took that work as a foundation and limited their focus to two strategies each. In the Lake Michigan blueprint, the top strategy is the creation of an interstate agreement for prevention and management of invasive species, an idea not addressed explicitly in the other blueprints, perhaps because of the unique situation of Lake Michigan being entirely in the US.

Connectivity/hydrology. Across all four blueprints, strategies were consistent in calling for cost–benefit analyses to evaluate connectivity restoration efforts, both to assess risks from invasive species and pathogen spread and to achieve the most important ecological outcomes. As expected, some issues reflected in the strategies particular to individual Great Lakes are not relevant to all. This is the case for regulation of water levels in Lake Ontario, which was the only blueprint with a strategy to restore more natural lake-level variability after decades of dampened water-level cycles in that lake.

Fish restoration. The need to restore native fish—both predators and midlevel prey species—in all four lakes is clear from the viability assessments of the open water benthic and pelagic zone, which rated this target as fair. This rating reflects the lack of lake trout natural reproduction (Bronte et al., 2008), the major disruption of the lower trophic levels [i.e., disappearance of the invertebrate *Diporeia* and dominance of nonnative mussels (Vanderploeg et al., 2012)], and declines in native fish populations (Madenjian et al., 2012). The Lake Ontario and Lake Michigan blueprints include strategies addressing fish restoration.

Nearshore water quality. In all the blueprints, reduction of non-point-source pollution from agricultural and urban sources is a featured strategy because of widespread recognition of the impacts of these pollutants on the nearshore zone. Indeed, the revised Great Lakes Water Quality Agreement has its entire Annex 4 devoted to nutrients and establishes interim substance objectives for phosphorus concentrations and total loads in all of the lakes (Government of the US and Government of Canada, 2012). All blueprints promote increased use of agricultural best management practices (BMPs) and target these BMPs to priority areas, and, in Lakes Huron and Michigan, increased valuation of ecosystem services to create more incentives for BMP use. Green infrastructure and other storm-water management

Table 4. Thematic comparison of strategies from four Great Lakes blueprints

Theme	Coastal conservation	Invasive species	Connectivity/ hydrology	Fish restoration	Nearshore water quality	Climate change adaptation
Lake Ontario	Protection Watershed planning Public lands management Private land stewardship	Ballast water Canals; ecological separation Recreational boating Live trade Rapid-response plan Control to benefit lake trout/native fish	Priority dams/barriers Hydropower-siting guidelines Restore lake-level variability	Restore predators and midlevel prey	BMPs in rural priority areas Decrease urban NPS	Corridors and linkages Adapt lake level and watershed management
Lake Huron	Coastal protection—system of conservation lands Coastal restoration Build local policy and planning Increase community engagement Integrative frameworks for coastal management	Restore native species Early-detection/rapid-response network Risk assessment Develop new control techniques Eliminate ballast-water vector	Integrative barrier management		Targeted agricultural BMPs Improved septic and conversion to sewers Incentives for ecosystem service protection Assess ecosystem service values Watershed vulnerability assessment	Educate public Monitor climate change and biodiversity in sentinel sites Assess ecosystem service value Watershed vulnerability assessment
Lake Michigan	Coordinate planning to align future development with biodiversity conservation	Interstate agreement Early-detection/rapid-response network	Comprehensive lowest barrier decision tool Increase connectivity at large scale	Restore cisco in Lake Michigan Broaden constituency for sea lamprey control	Agricultural community communication network Market mechanisms: nutrient trading Promote and implement Green Infrastructure & Strengthen NPS Management	(Incorporated into strategies)
Lake Erie	Build business case for coastal conservation Healthy shoreline education/outreach program	Common framework for control and management Coordinated action plan for common reed	Comprehensive lowest barrier decision tool		Increase nutrient management BMPs to lower SRP Promote infield drainage management Municipal storm-water management	(Incorporated into strategies)

BMP, best management practices; NPS, non-point-source pollution; and SRP, soluble reactive phosphorus.

Table 5. Conservation targets for which priority areas were identified in each of four Great Lakes blueprints

	Lake Ontario	**Lake Huron**	**Lakes Erie and Michigan**
Targets used to identify priority areas	Coastal wetlands Coastal terrestrial Nearshore zone Tributaries Migratory fish	Coastal wetlands Coastal terrestrial Aerial migrants Islands	Coastal wetlands Coastal terrestrial Aerial migrants Islands
Priority area units	Coastal units* Quaternary watersheds	Coastal units	Coastal units
Criteria to prioritize *coastal wetlands*	Biological significance 1. Number of native wetland-associated species and natural communities 2. Number of coastal wetland types 3. Percent of coastal unit that is wetland Condition 1. Percent natural land cover within coastal unit 2. Percent of shoreline with man-made structures	Ecosystem significance 1. Wetland area within coastal unit 2. Wetland regional rarity: wetland in coastal unit/wetland in ecoreach 3. Richness of tracked indicator species 4. Richness of wetland types (GLCWC) Coastal development footprint 1. Artificial shoreline percentage 2. Natural land cover within 2 km of shoreline 3. Natural land cover from 2 to 5 km from shoreline 4. Natural land cover within watershed 5. Road density within 2 km of shoreline (meters of road/km^2) 6. Building density within 500 m of shoreline (number of buildings/km^2) 7. Impervious surface in watershed	Biodiversity significance 1. Percent of coastal wetland area 2. Richness of globally rare wetland species (G1–G3) 3. Richness of globally rare wetland communities (G1–G3) 4. Richness of coastal wetland types 5. Frequency of globally rare terrestrial occurrences (G1–G3) Condition 1. Percent of natural land cover within watershed 2. Percent of natural land cover within 500 m of coastal wetlands

(continued)

Table 5. Continued

	Lake Ontario	Lake Huron	Lakes Erie and Michigan
Criteria to prioritize *coastal terrestrial*	Biological significance 1. Number of native nearshore-zone-associated species and communities 2. Number of nearshore subaqueous types Condition 1. Percent of shoreline with man-made structures 2. Watershed land disturbance index 3. Contributing area of watershed	Ecosystem significance 1. Natural land cover within 2 km of shoreline 2. Coastal complexity (length of coast: length of coastal unit) 3. Sand beach within coastal unit 4. Sand beach rarity: sand beach in coastal unit/sand beach in coastal ecoreach (%) 5. Cobble beach within coastal unit 6. Cobble beach rarity: cobble beach in coastal unit/cobble beach in coastal ecoreach 7. Bluff within coastal unit 8. Bluff rarity: bluff in coastal unit/bluff in coastal ecoreach 9. Cliff within coastal unit 10. Cliff rarity: cliff in coastal unit/cliff in coastal ecoreach 11. Richness of tracked indicator species 12. Richness of globally rare species 13. Richness of globally rare vegetation communities 14. Richness of coastal terrestrial types Coastal development footprint 1. Artificial shoreline percentage 2. Natural land cover within 2 km of shoreline 3. Natural land cover from 2 to 5 km from shoreline 4. Natural land cover within watershed 5. Road density within 2 km of shoreline (meters of road/km^2) 6. Building density within 500 m of shoreline (number of buildings/km^2) 7. Impervious surface in watershed	Biodiversity significance 1. Coastal shoreline complexity 2. Richness of globally rare terrestrial species (G1–G3) 3. Richness of globally rare terrestrial communities (G1–G3) 4. Richness of coastal terrestrial system types 5. Frequency of globally rare terrestrial occurrences (G1–G3) Condition 1. Percent natural shoreline 2. Percent natural land cover within 2 km of shoreline 3. Percent natural land cover within 2–5 km of shoreline 4. Road density within 2 km of shoreline 5. Building density within 500 m of shoreline/km^2 6. Number of bedload traps and groins/100 km

(continued)

Table 5. Continued

	Lake Ontario	Lake Huron	Lakes Erie and Michigan
Criteria to prioritize *nearshore zone*	Biological significance 1. Number of native terrestrial-associated species and communities 2. Number of shoreline geomorphic types Condition 1. Percent of shoreline with man-made structures 2. Watershed land disturbance index 3. Contributing area of watershed	NA	NA
Criteria to prioritize *migratory fish*	Biological significance (Expert input) Condition 1. Percent of total stream length within the watershed connected to Lake Ontario 2. Percent natural cover within watershed	NA	NA
Criteria to prioritize *aerial migrants*	NA	Ecosystem significance 1. Very high or high significance stopover habitat in coastal unit 2. Stopover rarity: priority stopover habitat in coastal unit/priority stopover habitat in coastal ecoreach	Priority habitat for migrating landbirds, shorebirds, and waterfowl as mapped by Ewert et al. (2012)
Criteria to prioritize *tributaries*	Biological significance 1. Total number of native fish species 2. Fish and mussel rarity 3. Fish irreplaceability Condition 1. Natural cover 2. Agricultural land cover 3. Tributary connectivity	NA	NA
Criteria to prioritize *islands*	NA	Scores for biological significance from Great Lakes Islands Project used Islands also assessed based on other targets	Scores for biological significance from Great Lakes Islands Project used Islands also assessed based on other targets
Other	NA	Conservation capacity	Ecosystem goods and services
Approach to defining priority areas	All top-scoring areas for biological significance highlighted. Map showing areas with overlapping target priorities.	All top-scoring areas for ecosystem significance highlighted. Map showing areas with overlapping target priorities.	Maps show scores for all coastal units for coastal wetlands and coastal terrestrial systems. Priority regions described.

G1–G3, NatureServe conservation status ranks of G1 (critically imperiled), G2 (imperiled), or G3 (vulnerable) (NatureServe Explorer, 2013); GLCWC, Great Lakes Coastal Wetland Consortium wetland classification (Albert et al., 2005); and NA, not addressed.

strategies were identified in the Lake Erie and Lake Michigan blueprints, reflecting a growing awareness of the benefits of these strategies, both to water quality and to other aspects of quality of life (cf. Adesoji et al., 2012; Flakne and Keller, 2012).

Climate change. Climate change was identified as a top threat to biodiversity in each of the blueprints, and each blueprint considered the potential impacts of future climate conditions on each of the conservation targets, providing details on important ecological attributes or processes that are likely to change. So that the strategies would be "climate smart," these potential impacts were incorporated into the assessment of viability and the development of strategies.

The blueprints vary in their approach to addressing the threat of climate change. Some blueprints identify actions specific to increasing effectiveness of climate change adaptation measures, advocating for greater resiliency through planning for corridors and identifying most vulnerable areas. In the Lake Ontario blueprint, one of the top six recommendations is to plan and adapt for climate change, and the report lists two strategies related to improving landscape connectivity and modifying lake-level management to incorporate the effects of future climates. The Lake Huron report provides a conceptual diagram of the relationship of climate change to conservation targets and many other threats, such as lower lake levels increasing the likelihood of nonnative species invading coastal wetlands. It then incorporates climate change into strategies that apply to other threats—strategies such as removing dams and barriers in streams and incorporating resilience into identifying priorities for ecosystem restoration. Similarly, the Lake Michigan and Lake Erie blueprints provide a synopsis of potential climate change impacts but do not focus on strategies specifically to address climate change. Rather, climate change impacts and adaptation strategies were considered and incorporated into other strategies where relevant. These varying approaches to addressing climate change in conservation strategies reflect the relatively new practice of developing climate change adaptation strategies and the differing levels of understanding of climate change adaptation by resource managers (Petersen et al., 2013).

Identifying Priority Areas

Participants in each blueprint project expressed the desire for a detailed map of priority conservation areas that focused primarily on coastal and aquatic systems. Project teams used slightly different approaches to providing this information (Table 5). For a subset of conservation targets in each blueprint, priority areas were considered in terms of two broadly defined factors: (a) ecological or biological significance and (b) condition, characterized as *coastal footprint* in the Lake Huron blueprint. Coastal terrestrial systems and coastal wetlands were included in all blueprints, and additional targets including aerial migrants, tributaries, islands, and migratory fish were considered in some. The criteria used to assess these two factors differed somewhat as well, and each employed a framework of spatial planning units, such as *coastal units* (defined as the intersection of watershed boundaries—quaternary watersheds in Ontario, and Hydrologic Unit Classification level-11 watersheds in the US—and the coast, plus 2 km of inland buffer) rather than predetermined site boundaries (Table 5). The Lake Ontario blueprint also identified priority watersheds and nearshore areas.

The Lake Ontario blueprint identifies 23 "Proposed Action Sites," mostly watersheds, as well as a few coastal units, bays, and nearshore areas (Lake Ontario Biodiversity Strategy Working Group, 2009). Each site was identified as important for the conservation of particular targets, and the blueprint recommends actions for conserving those targets. The priority areas were identified by experts through analysis and review of maps of the targets in a series of workshops, and the blueprint acknowledges gaps in expertise and recommends revisiting the priorities regularly.

The Lake Huron blueprint provides maps of ecological significance and condition for coastal terrestrial systems, coastal wetlands, aerial migrants, and islands, and also a synthesis of these targets stratified among nine subregions of the lake. These subregional priorities are intended for use by local practitioners in each part of the lake.

The Lake Erie and Lake Michigan blueprints provide maps of ecological significance and condition for coastal terrestrial systems and coastal wetlands, and priority maps for aerial migrants and islands, but do not synthesize these. The maps of coastal units are coded on a gradient from low to high significance or poor to good condition and can inform practitioners in each region of the lake. Priority islands for the latter three blueprints were based on a recent Great Lakes–wide analysis (Henson et al., 2010).

Ecosystem Services

The Lake Erie and Lake Michigan blueprints also provide an initial assessment that addresses two general questions that were answered through online surveys: (a) What are

Table 6. Top ten most important ecosystem services in Lakes Erie and Michigan

Lake Michigan rank	Lake Erie rank	Service
2	1	Cultural services: recreation and tourism (lake recreation, wild game, songbirds, other wildlife)
4	2	Supporting services: provision of habitat (biodiversity support, habitat diversity)
1	3	Provisioning services: fresh water (water supply)
3	4	Supporting services: primary production (energy capture, food-chain support, energy flow for fish, benthic food chain)
6	5	Cultural services: aesthetic values (aesthetics)
10	6	Supporting services: nutrient cycling (nutrient storage)
5	7	Regulating services: water purification and waste treatment (water quality, waste assimilation, groundwater quality)
9	8	Cultural services: sense of place
7	9	Supporting services: water cycling (soil moisture storage)
8	10	Regulating services: climate regulation (carbon storage, moderation of weather extremes)

the most important ecosystem services[2] provided by the lake and its coastal area? (b) What would be the general impact of the recommended strategies on the 10 most important ecosystem services?

Of the 32 ecosystem services considered in the Lake Erie and Lake Michigan blueprints, the 10 that were ranked most important in each lake were the same, though they ranked in slightly different order (Table 6) (Pearsall et al., 2012a,b). These included recreation and tourism, freshwater supply, primary production, aesthetic values, nutrient cycling, water purification and waste treatment, sense of place, water cycling, and climate regulation.

Lessons Learned and Recommendations

The Great Lakes conservation blueprints, while providing specific guidance to collaborative, adaptive management of each lake ecosystem, are also models for the application of the Open Standards to a large-scale system. Each step of the planning process involves method choices and interpretation of results. Listed next are eight recommendations based on lessons learned from this planning process that have value for Great Lakes conservation practitioners and well beyond to anyone involved in landscape-scale conservation planning.

1. Engage Representative Stakeholders.

Although engaging diverse and widely dispersed participants presents logistical challenges, we found that the approach of designating a large, representative steering committee facilitated diverse input. To manage these large, dispersed committees, we employed monthly conference calls that enabled more frequent communication than if we had tried to meet directly. Each Steering Committee was characterized by a strong core of members who regularly and substantially contributed to the process. We also recommend broadening participation and reducing costs by limited in-person workshops and using webinars and online surveys, as we did to assess viability and threats in Lakes Erie and Michigan.

The blueprints are multijurisdictional at national and state or provincial scales and have engaged a diverse set of natural resource agency, NGO, and university stakeholders in their development; however, some groups, such as corporations and municipal officials, were underrepresented. Their perspective would have helped with strategies for which local government is the primary locus of resource use decisions. The blueprints have been strongly supported by the USEPA and EC, who administer the LAMPs. We recommend continued stakeholder engagement through the LAMPs to enable effective, collaborative implementation in communities across the Great Lakes.

2. Use Stratification Units to Report Results at Various Spatial Scales and Account for Regional Heterogeneity, Despite the Extra Effort Involved.

An overall viability assessment on such large, diverse geographies can mask underlying spatial variation in target viability and indicator status. The current status of conservation targets is mostly consistent among the lakes at a lake-basin scale. Considerable spatial variability characterizes some of the targets, reflecting variation in land use, climate, and other factors. Some of the blueprints dealt with this spatial variability through geographic stratification of the lakes to provide the most useful information to practitioners, and to provide comprehensive results by these smaller units. Still, reporting at a lakewide scale, though not necessarily useful for local stakeholders, is valuable to state, provincial, and federal managers and decision makers and, indeed, is the premise for the SOLEC, which reports on a comprehensive set of indicators at basinwide and lake-basin scales (Environment Canada and US Environmental Protection Agency, 2009).

Stratifying the lakes through use of a hierarchical, ecologically based set of units in the Lake Michigan and Lake Erie blueprints provided useful detail in the viability and threat assessments, such as which indicators and which locations drive the assessment values. The approach also required considerably more effort because ratings for viability and threats at the assessment-unit scale were aggregated to the reporting units and whole-lake scale. The approach for aggregating values is not without challenges, as many of the viability indicators were rated on constructed, rather than natural, scales. In other words, the indicator values were assigned to categories ranging from poor to very good, and then these values were aggregated by using rules adapted from the Conservation Measures Partnership. We had few models on which to base this aggregation process and had to modify the process when we encountered problems related to averaging values that are not truly quantitative. Even given these challenges, project participants expressed support for the finer level of detail. Given the perceived value of the stratified assessments, further refinement of the aggregation process is warranted.

3. Viability and Threat Assessments Should Be Refined as New Information Becomes Available.

There is considerable room for refinement of the viability and threat assessments as new information becomes available, and we recommend increased coordination on development and monitoring of status indicators for each lake and among lakes as other initiatives to improve indicators, such as those by the International Joint Commission (IJC), progress. The IJC is currently developing a short list of indicators that will be applied at the whole-lake and Great Lakes–basin scales, building on recent reviews of the SOLEC indicators; a broader set of indicators to better inform regional and local managers should be clearly linked to this short list. Our initial estimates of viability and threats provide a baseline but, more importantly, highlight some key data gaps and explicitly tie these assessments to conservation strategies.

4. Threat Assessments Should Account for Professional or Regional Bias.

The transition in threat assessment methodology to a survey of experts for Lakes Erie and Michigan was intended both to increase the level of engagement of experts and to reduce the bias inherent in prior blueprints that employed a workshop approach to achieve group consensus. The number of participants in the threat-rating surveys varied among threats and was generally slightly higher than participation in the threat workshops of early blueprints. The Lake Ontario and Lake Huron project teams recognized the influence of more dominant or extrovert personalities among the workshop participants and employed group facilitation techniques to achieve more equitable participation. The online surveys used in the later blueprints enabled all participants to contribute equally, and the project teams evaluated the expertise of the survey participants, weighing the responses of those with demonstrated expertise more heavily. This approach incorporates some of the recommendations by Burgman et al. (2011) for expert elicitation. Although more objective methods of assessing threats were available (Allan et al., 2013), the time line and the funding restrictions of these planning processes did not allow for such detailed studies. However, in an adaptive management framework, revisions of the blueprints can build upon these threat assessments.

5. Give Equal Weight to Restoration Needs in Strategy Development.

As is common in CAP, the blueprints focus on abating critical threats rather than restoring viability. The viability status in the four Great Lakes assessed so far has been rated predominantly as fair, reflecting a need for restoration of many ecological attributes. We recommend that future applications of this process to large-scale ecosystems evaluate the potential benefits of restoration of conservation target viability on an equal basis with threat abatement strategies. In completing these four blueprints, teams focused almost exclusively on threat abatement when selecting the top five topics for strategy development, to the near exclusion of restoration strategies (fishery restoration strategies for Lakes Ontario and Michigan being the only exceptions). Plans may not be paying enough attention to restoration needs integral to improving overall ecosystem health.

6. Define the Scope of Strategies and Key Constraints at the Outset.

Four main factors contributed to the selection of specific strategies to feature in the blueprints: the highest-ranked threats, input of the steering committees, the particular experts who participated in the workshops, and what strategies were already being pursued in a given topic area in each lake. The time available in the workshops and for phone conferences limited how many strategies could be developed in any detail—so, while participants brainstormed longer lists, the workshop discussions were focused on those strategies that were thought to have the greatest potential impact and feasibility. Thus, the blueprints are not intended to cover every strategy needed, but rather to present a priority portfolio of strategies. In a region where a lot of planning has occurred at multiple scales, the value of strategy development lies in the reassessment of the priority and feasibility of strategies given current and predicted circumstances. Two benefits derived from building on previous conservation planning are enhanced visibility for local strategies and greater buy-in from a diverse planning group. Planning teams also encouraged novel strategies, such as building a business case for coastal conservation in Lake Erie. We recommend the following two questions be addressed at the outset of the planning process: First, does the plan need to be comprehensive in terms of strategies? If not, then what does the decision to feature one strategy over another actually mean? Defining the scope of the strategies will help participants understand their charge, and this clarity will support implementation.

7. Priority-Area Identification in the Context of Conservation Planning for Large Ecosystems Should Provide General Guidance, Representing a First Step.

Participants in all four blueprints expressed a desire for guidance on where to take action to conserve and restore biodiversity. The information provided by the blueprints identifies general regions of higher priority but does not highlight particular tracts or parcels and, in most cases, is limited to one or a few kinds of strategies (e.g., for land and water conservation). Also, the analyses do not incorporate numeric or spatial goals for representation of species and natural communities, two parameters that are often the basis for regional assessments. Still, the information can be used by regional and local natural resource managers and planners to highlight areas within which particular values—for example, conservation of coastal wetlands—should be a priority and to consider these local areas from a lakewide perspective. More rigorous priority setting at the regional and subregional scales is needed, such as updating the *Binational Blueprint for Conservation of the Great Lakes* (TNC and NCC, 2006).

8. Evaluate How Implementing Conservation Strategies Will Benefit People.

The majority of participants in the ecosystem services surveys for the Lake Erie and Lake Michigan blueprints were employees of public agencies or NGOs that play some role in managing or conserving the lakes. Thus, the ecosystem services assessments provide a broad overview of how one relatively homogeneous group of people perceives the benefits derived from Lakes Erie and Michigan. The findings are still valuable in that they provide insight into the reasons behind management decisions or about potential actions that would have support among that group of people. A survey of a fuller array of stakeholders may help implementation of the strategies, especially key financial and political stakeholders (e.g., farmers, local officials, charter captains, and outfitters). Also, the Open Standards were revised recently to include human well-being targets at the outset of a project, which would also help to establish explicit links among biodiversity, strategies, and human values.

Conclusions

These biodiversity conservation strategies, mostly consistent in structure and findings, provide a basis and a general direction for a collaborative, adaptive approach to managing and conserving four of the five Great Lakes. The strategies define a focus for conservation efforts, identify ambitious goals, and establish quantitative measures for tracking progress toward goals. They report on the most critical threats to biodiversity and articulate strategies and actions for abating those threats and restoring the lakes. To varying degrees, they identify priority areas for some conservation actions and call for more effective collaboration, coordinated investments, and accountability.

The blueprints all recommend actions to abate the threats posed by invasive species (aquatic and terrestrial), incompatible development, non-point-source pollution, and dams and other barriers to fish passage, and two recommend restoration of native fish species. Each blueprint addresses the threat of climate change, as well: one through adaptation and outreach strategies, and three by incorporating climate impacts into other relevant strategies. This consistency among the blueprints reflects a broadly shared understanding of necessary actions among Great Lakes managers and conservation practitioners, and each blueprint provides greater detail that reflects opportunities and constraints specific to each lake. The blueprints are first iterations that, to be effective, must be adopted and refined by their respective stakeholders.

These blueprints address only the initial phases of the adaptive management process—defining the project and developing strategies—leaving implementation, monitoring, and adaptation to the stakeholders associated with each lake. Lake Ontario provides good examples of how the blueprints are already being adopted and implemented. First, the Lake Ontario LAMP adopted five of the six recommendations in the Lake Ontario blueprint, excluding only adaptation to climate change. Specifically, they chose to focus on these recommendations: (a) conserve critical lands and waters, (b) reduce the impact of aquatic invasive species, (c) restore connections and natural hydrology, (d) restore native fish communities and native species, and (e) restore the quality of nearshore waters (Lake Ontario LAMP, 2011). Equally important is that several of these recommendations are being implemented in New York State (David Klein, Senior Field Representative, TNC, personal communication, 2012). Ongoing projects include protecting land in priority watersheds, restoring native fish, developing recommendations for managing flows in tributary streams, restoring wetlands in priority watersheds, monitoring wetlands in support of a new Lake Ontario water-level management plan, modeling and surveys for aquatic invasive species in three states (which also incorporate the Lake Erie watershed), and ground truthing of recent maps of migratory bird stopover habitat. Funding for these projects totals over $3.8 million and comes from multiple sources, including the Great Lakes Restoration Initiative, the North American Wetlands Conservation Act, the National Oceanic and Atmospheric Administration, and the Great Lakes Protection Fund.

As Lake Ontario exemplifies, significant progress can be made when the LAMPs and their associated agencies, partners, and stakeholders adopt the recommendations and pursue adaptive management. Given that each LAMP will be updated every five years, one per year, the time is ripe to integrate goals, measures, and conservation actions that incorporate biodiversity into the LAMPs. Effective adaptive management will require continued investment, such as that provided by the USEPA through the Great Lakes Restoration Initiative and by Environment Canada via the Great Lakes Action Plan and Great Lakes Nutrient Initiative. The blueprints clearly could not have been developed without investments such as these, and improving long-term ecological health in the Great Lakes will require continued investments tied to actions that lead to outcomes that restore the essential ecological drivers of our Great Lakes system for the use and enjoyment of all.

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Notes

1. The term *strategies* here refers to groups of actions designed to restore natural systems, reduce threats, or develop capacity.
2. Ecosystem services followed the classification of the Millennium Ecosystem Assessment (Conceptual Framework Working Group, 2003).

References

Adesoji, A., M. Gibson, J. Paskus, B. Klatt, Y. Hailu, T. Borowy, B. Calnin, and E. Schools. 2012, February 3. *Drivers of Economic Importance in Michigan: Natural Features, Green Infrastructure and Social/Cultural Amenities*. Land Policy Institute (LPI) New Economy Report Series LPR–2011–NE–04. Michigan State University LPI, East Lansing, 72 pp. Available at http://mnfi.anr.msu.edu/reports/2012-08_Drivers_of_Economic_Performance_in_Michigan.pdf (accessed March 18, 2013).

Albert, D.A., D.A. Wilcox, J.W. Ingram, and T.A. Thompson. 2005. Hydrogeomorphic Classification for Great Lakes Coastal Wetlands. *Journal of Great Lakes Research* 31(1):129–146.

Allan, J.D., P.B. McIntyre, S.D.P. Smith, B.S. Halpern, G.L. Boyer, A. Buchsbaum, G.A. Burton Jr., L.M. Campbell, W.L. Chadderton, J.J.H. Ciborowski, P.J. Doran, T. Eder, D.M. Infante, L.B. Johnson, C.A. Joseph, A.L. Marino, A. Prusevich, J. Read, J.B. Rose, E.S. Rutherford, S.P. Sowa, and A.D. Steinman. 2013. Joint Analysis of Stressors and Ecosystems Services to Enhance Restoration Effectiveness. *Proceedings of the National Academy of Sciences USA* 110(1):372–377.

Anderson, M., and C. Ferree. 2010. Conserving the Stage: Climate Change and the Geophysical Underpinnings of Species Diversity. *PLoS ONE* 5(7):e11554.

Bronte, C.R., C.C. Krueger, M.E. Holey, M.L. Toneys, R.L. Eshenroder, and J.L. Jonas. 2008, April. *A Guide for the Rehabilitation of Lake Trout in Lake Michigan*. Misc. Publ. 2008-01. Great Lakes Fishery Commission, Ann Arbor, MI, 41 pp. Available at http://www.glfc.org/pubs/pub.htm#misc (accessed August 29, 2012).

Burgman, M., A. Carr, L. Godden, R. Gregory, M. McBride, L. Flander, and L. Maguire. 2011. Redefining Expertise and Improving Ecological Judgment. *Conservation Letters* 4(2):81–87.

Conceptual Framework Working Group of the Millennium Ecosystem Assessment. 2003. *Ecosystems and Human Well-being: A Framework for Assessment*. Island Press, Washington, DC, 245 pp.

Conservation Measures Partnership. 2013, April. *Open Standards for the Practice of Conservation, Version 3.0*. 47 pp. Available at http://www.conservationmeasures.org/wp-content/uploads/2013/05/CMP-OS-V3-0-Final.pdf (accessed May 2, 2013).

Environment Canada and US Environmental Protection Agency. 2009. *State of the Great Lakes 2009*. Environment Canada, Toronto, and US Environmental Protection Agency, Chicago, 437 pp. Available at http://binational.net/solec/sogl2009/SOGL_2009_en.pdf (accessed August 29, 2012).

Ewert, D.N., P.J. Doran, K.R. Hall, A. Froehlich, J. Cannon, J.B. Cole, and K.E. France. 2012, November. *On a Wing and a (GIS) Layer: Prioritizing Migratory Bird Stopover Habitat along Great Lakes Shorelines*. Final Report to the Upper Midwest/Great Lakes Landscape Conservation Cooperative. The Nature Conservancy, Lansing, MI, 86 pp. Available at http://glmigratorybirds.org/downloads/LCC_PhaseIStopover_Report_Final.pdf (accessed May 2, 2013).

Flakne, R., and R. Keller. 2012. A Plan for Nature in Glenview: Creating and Implementing a Natural Resources Plan at the Community Level. *Environmental Practice* 13(1):35–44.

Franks Taylor, R., A. Derosier, K. Dinse, P. Doran, D. Ewert, K. Hall, M. Herbert, M. Khoury, D. Kraus, A. Lapenna, G. Mayne, D. Pearsall, J. Read, and B. Schroeder. 2010, June. *The Sweetwater Sea: An International Biodiversity Conservation Strategy for Lake Huron: Technical Report*. The Nature Conservancy, Environment Canada, Ontario Ministry of Natural Resources, Michigan Department of Natural Resources and Environment, Michigan Natural Features Inventory Michigan Sea Grant, and The Nature Conservancy of Canada, Lansing, MI, 264 pp. with appendices. Available at http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/biodiversity/Pages/default.aspx (accessed May 18, 2013).

Government of Canada and US Environmental Protection Agency. 1995. *The Great Lakes: An Environmental Atlas and Resource Book*, 3rd edition. Environment Canada, Toronto, 46 pp. Available at http://www.epa.gov/glnpo/atlas/ (accessed August 29, 2012).

Government of the United States and Government of Canada. 1987. *Protocol Amending the 1978 Agreement between the United States of America and Canada on Great Lakes Water Quality, as Amended on October 16, 1983*. Consolidated by the International Joint Commission, Washington, DC, and Ottawa, 41 pp. with annexes. Available at http://epa.gov/grtlakes/glwqa/1978/index.html (accessed March 18, 2013).

Government of the United States and Government of Canada. 2012, September 7. *Protocol Amending the Agreement between the United States of America and Canada on Great Lakes Water Quality*. US Government Printing Office, Washington, DC, 75 pp. with annexes. http://www.epa.gov/greatlakes/glwqa/20120907-Canada-USA_GLWQA_FINAL.pdf (accessed March 18, 2013).

Henson, B.L., K.E. Brodribb, and J.L. Riley. 2005. *Great Lakes Conservation Blueprint for Terrestrial Biodiversity*, volume 1. Nature Conservancy of Canada and Ontario Ministry of Natural Resources, Toronto, 157 pp. with appendices.

Henson, B.L., D.T. Kraus, M.J. McMurty, and D.N. Ewert. 2010. *Islands of Life: A Biodiversity and Conservation Atlas of the Great Lakes Islands*. Nature Conservancy of Canada, Port Rowan, 154 pp.

Knight, A.T., R.M Cowling, and B.M. Campbell. 2006. An Operational Model for Implementing Conservation Action. *Conservation Biology* 20(2):408–419.

Lake Ontario Biodiversity Strategy Working Group. 2009, April. *The Beautiful Lake: A Binational Biodiversity Conservation Strategy for Lake Ontario*. The Nature Conservancy, Nature Conservancy Canada, and US–Canada Lake Ontario Lakewide Management Plan. Nature Conservancy of Canada, Toronto, 40 pp. Available at http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/biodiversity/Pages/default.aspx (accessed May 18, 2013).

Lake Ontario LAMP (Lakewide Action and Management Plan) Work Group and Technical Staff. 2011, April. *Implementing a Lake Ontario LaMP Biodiversity Conservation Strategy. Lake Ontario Lakewide Management Plan*. 43 pp. Available at http://www.epa.gov/greatlakes/lakeont/lake-ontario-biodiversity-conservation-strategy-201104.pdf (accessed March 18, 2013).

Lake Superior Lakewide Action and Management Plan (LAMP)–Superior Work Group (SWG). 2013, February. *A Biodiversity Conservation Assessment for Lake Superior* [Draft]. 117 pp. Available at http://support.natureconservancy.ca/pdf/on/lake-superior/DRAFT_Lake-Superior-Biodiversity-Conservation-Assessment_22Feb2013.pdf (accessed May 18, 2013).

Madenjian, C.P., D.B. Bunnell, T.J. Desorcie, M.A. Chriscinske, M.J. Kostich, and J.V. Adams. 2012, March 19. *Status and Trends of Prey Fish Populations in Lake Michigan, 2011*. Presented at Great Lakes Fishery Commission, Lake Michigan Committee Meeting, Windsor, Canada.

The Nature Conservancy (TNC). 2000. *Towards a New Conservation Vision for the Great Lakes Region: A Second Iteration*. TNC, Chicago, 46 pp.

The Nature Conservancy (TNC). 2007. *Conservation Action Planning Handbook: Developing Strategies, Taking Action and Measuring Success at Any Scale*. TNC, Arlington, VA, 129 pp.

The Nature Conservancy (TNC) and Nature Conservancy of Canada (NCC). 2006. *Binational Blueprint for Conservation of the Great Lakes*. TNC, Chicago, and NCC, Port Rowan, 12 pp.

NatureServe Explorer. 2013. *NatureServe Conservation Status*. Available at http://www.natureserve.org/explorer/ranking.htm#globalstatus (accessed May 18, 2013).

Pearsall, D., P. Carton de Grammont, C. Cavalieri, C. Chu, P. Doran, L. Elbing, D. Ewert, K. Hall, M. Herbert, M. Khoury, D. Kraus, S. Mysorekar, J. Paskus, and A. Sasson. 2012a. *Returning to a Healthy Lake: An International Biodiversity Conservation Strategy for Lake Erie*. Technical Report. The Nature Conservancy, Nature Conservancy of Canada, and Michigan Natural Features Inventory, Lansing, MI, 340 pp. with appendices. Available at http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/biodiversity/Pages/default.aspx (accessed May 18, 2013).

Pearsall, D., P. Carton de Grammont, C. Cavalieri, P. Doran, L. Elbing, D. Ewert, K. Hall, M. Herbert, M. Khoury, S. Mysorekar, S. Neville, J. Paskus, and A. Sasson. 2012b. *Michigami: Great Water—Strategies to Conserve the Biodiversity of Lake Michigan*. Technical Report. The Nature Conservancy and Michigan Natural Features Inventory, Lansing, MI, 313 pp. with appendices. Available at http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/michigan/projects/biodiversity/Pages/default.aspx (accessed May 18, 2013).

Petersen, B., K.R. Hall, P.J. Doran, and K. Kahl. 2013. In Their Own Words: Perceptions of Climate Change Adaptation from the Great Lakes Region's Resource Management Community. *Environmental Practice* 15(4) [in this issue].

Rodriguez, K.M., and R.A. Reid. 2001. Biodiversity Investment Areas: Rating the Potential for Protecting and Restoring the Great Lakes Ecosystem. *Ecological Restoration* 19(3):135–144.

Vanderploeg, H.A., S.A. Pothoven, G.L. Fahnenstiel, J.F. Cavaletto, J.R. Liebig, C.A. Stow, T.F. Nalepa, C.P. Madenjian, and D.B. Bunnell. 2012. Seasonal Zooplankton Dynamics in Lake Michigan: Disentangling Impacts of Resource Limitation, Ecosystem Engineering, and Predation during a Critical Ecosystem Transition. *Journal of Great Lakes Research* 38(2):336–352.

Wichert, G.A., K.E. Brodribb, B.L. Henson, and C. Phair. 2005. *Great Lakes Conservation Blueprint for Aquatic Biodiversity*, volume 1. Nature Conservancy of Canada and Ontario Ministry of Natural Resources, Toronto, 86 pp. with appendices.

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