In Their Own Words: Perceptions of Climate Change Adaptation from the Great Lakes Region's Resource Management Community

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In response to observed and projected changes in climate, efforts to promote climate change adaptation to key stakeholder groups have been rapidly increasing. To help us understand the perceptions of resource managers in the Great Lakes region, we conducted a Web-based survey. We asked respondents to define *climate change adaptation* and to provide examples of both feasible and current adaptation actions. Responses from 441 individuals indicate that many did not have a clear, proactive concept of climate change adaptation. Only 74% provided a definition, and, of those, only 43% described adaptation as a proactive process. Nearly one third (30%) gave purely reactive descriptions, and 27% failed to convey the concept of intentionally responding to climate change impacts; half of these described climate change mitigation or evolutionary adaptation. Examples of *feasible* actions covered a range of current conservation practices and some adaptation-specific ideas (e.g., research on potential species' range shifts, managed relocation of species), along with such actions as updates to infrastructure. In comparison to feasible actions, actions identified as *under way* were biased toward early stages in adaptation, such as science and planning, increasing awareness, and capacity building. We suggest that targeted outreach can help catalyze movement from early-stage actions toward implementation of change: collaborative work with stakeholders to refine and customize the concept of adaptation and develop visions of successful adaptation is vital to the long-term conservation of the Great Lakes ecosystem.

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The rapid rate and pervasive nature of climate change impacts suggest that our resource management approaches will need to keep pace, and likely transform, in order to protect people and nature over the long term (Ehrlich and Pringle, 2008; Kates, Travis, and Wilbanks, 2012; Lawler et al., 2010; Marshall et al., 2012; Park et al., 2012). Efforts to promote adaptation to key stakeholder groups have been rapidly increasing: guidance documents, tools, workshops, and websites are being developed at all levels of government, in nongovernmental organizations, and in the private sector (Bierbaum et al., 2013). However, reviews of current adaptation actions suggest that, relative to the efforts invested in promoting adaptation, actual implementation of change is rare, and change tends to be incremental (Bierbaum et al., 2013; Eisenack et al., 2012; Lemieux et al., 2011). Discussions of barriers to adaptation suggest that the information and tools presented to stakeholders often miss the mark; information may not be presented in useful forms or at the right time, or may not account for differences among resource managers in underlying risk perceptions, beliefs, and values (e.g., Adger et al., 2009; Doria et al., 2009; Moser and Ekstrom, 2010). Like the specific strategies needed to reduce climate-related risks in a given region, the guidance, tools, and information that will be most useful in helping stakeholders move forward on adaptation will vary from place to place. For those investing in programs or guidance to promote adaptation, how best to motivate stakeholders and to empower them are key questions that are likely best answered through understanding what the audience knows, how they

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define key terms, and what they value (Moser and Ekstrom, 2010).

In natural resource management and conservation fields, climate change is well recognized as having significant consequences for the maintenance of biodiversity, ecological systems, and ecosystem services (Bardsley and Sweeney, 2010; Geyer et al., 2011; Parmesan and Yohe, 2003; Root et al., 2003; Warren et al., 2013). Although many factors contribute to species losses at local and global scales, climate change in the coming decades will likely supplant habitat loss as the primary threat to biodiversity (Leadley et al., 2010). Climate change is also increasing storm intensities and the frequency of drought and heat waves, changing fire regimes, and promoting the spread of some pests and pathogens (Hayhoe et al., 2010; Lawler et al., 2010). Changes in these key climate-related factors, and their interactions with current stressors like land use change, pollution, and nonnative invasive species, pose significant challenges for natural resource managers (Allan et al., 2013; Baron et al., 2009; Lawler, 2009).

Current greenhouse-gas levels in the atmosphere make continued climate change inevitable (Solomon et al., 2009). Thus, long-term maintenance of diverse natural systems requires that we succeed on two fronts: slowing the rate of climate change by reducing emissions, and responding to the increased risks to species and natural systems that are resulting from changes in key climate drivers. While it is straightforward to suggest that resource managers will be most effective at reducing risks if they can be proactive, and can initiate transformative changes when appropriate, history and experience tell us that resource management entities, and societies in general, tend to respond reactively (Bierbaum et al., 2013; Ehrlich and Pringle, 2008). Thus, the range of actors working to promote adaptation among the natural resource management and conservation community face a similar question: How do we target our investments in resources and activities to promote proactive adaptation?

Understanding Climate Change Adaptation in the Great Lakes Region

As researchers and conservation practitioners in the Great Lakes region, we were interested in exploring knowledge and perceptions among our peers that would provide important context for understanding how to target efforts to promote adaptation in this region. We therefore developed a Web-based survey that we deployed to Great Lakes resource managers, conservation practitioners, planners, researchers, and others in the region. This article reports on two components of this survey: (1) stakeholders' concept of the definition of adaptation, and (2) how they operationalize the concept in terms of describing adaptation actions. To provide context for the responses on climate change adaptation definitions and actions, we provide answers to additional questions from the broader set in the full survey. The answers we report include demographic characteristics of our respondents, some information on their perceptions of climate change impacts, and the extent to which they address climate change in their jobs.

Our primary goal was to evaluate the extent to which this group of stakeholders shares a common understanding of the term *climate change adaptation* and to understand the typical components of, and range of variation among, their definitions. Published definitions of climate change adaptation vary in terms of specific objectives and language, the target of adaptation (people, or some combination of social and ecological systems), and the relative balance of anticipatory or reactive intention (Table 1). To see how stakeholders in our region define climate change adaptation, our survey asked an open-ended definition question, as well as several closed questions, to evaluate current understanding of the term and perception of the term's clarity. We expected definitions in our region to vary even more widely than published definitions because the concept of adapting to climate change is still fairly new and likely to be confused with other concepts, such as *climate change mitigation* (reducing the rate of climate change by reducing greenhouse-gas emissions). Alternatively, as many resource managers have a background in the biological sciences, we also expected that climate change adaptation definitions might overlap with concepts of biological or evolutionary adaptation—that is, the gradual change in species that occurs passively as a result of selective pressure.

We propose that because effective natural resource management in an interconnected system like the Great Lakes basin requires high levels of coordination and cooperation, wide variation in how people understand or define the term could slow progress toward implementation of adaptation actions. Given the current and potential stresses on biodiversity in the region (Allan et al., 2013), and the long time periods required for successful implementation of many types of protective actions (e.g., reconnection of natural areas in floodplains, changing land use regulations in the coastal zone), we were also interested in exploring the extent to which definitions of climate change adaptation suggested and supported anticipatory, or even

Table 1. Examples of definitions of climate change adaptation.

Source	Adaptation definition
IPCC Third Assessment (McCarthy et al., 2001) Well-established, consensus-based definition from the Intergovernmental Panel on Climate Change (IPCC).	*Adaptation* is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.
UNFCCC Secretariat (1992) Presented at the United Nation's Framework Convention on Climate Change (UNFCCC).	Practical steps to protect nations and communities from the likely disruption and damage that will result from effects of climate change.
Moser and Ekstrom (2010) Developed in response to the IPCC definition: key changes include an explicit linking of people and nature in social-ecological systems and inclusion of the concept of transformation.	Adaptation involves changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting nonclimatic changes. Adaptation strategies and actions can range from short-term coping to longer-term, deeper transformations; aim to meet more than climate change goals alone; and may or may not succeed in moderating harm or exploiting beneficial opportunities.
Doria et al. (2009) Developed through an expert elicitation process to define successful adaptation.	*Successful adaptation* is any adjustment that reduces the risks associated with climate change, or vulnerability to climate change impacts, to a pre-determined level, without compromising economic, social, and environmental sustainability
Hansen and Hoffman (2011) Guidance for practitioners.	"[H]uman efforts to reduce the negative effects of or respond to climate change, rather than evolutionary or biological adaptation" (p. 2).

transformative, changes in practices, rather than reactive actions.

To see how concepts of adaptation were translated to actions, we asked Great Lakes stakeholders to provide two types of examples of adaptation actions: feasible actions that could be implemented, and examples of actions that they were actually engaged in within the region. The Intergovernmental Panel on Climate Change (IPCC) describes *adaptation practices* as "actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate" (Adger et al., 2007, p. 720). Within the conservation and resource management literature are many sources of recommendations and general principles for how to help natural systems adapt (e.g., Hansen and Hoffman, 2011; Hobbs et al., 2010; Joyce et al., 2009; Lawler et al., 2010; West et al., 2009). For example, a widely cited review by Heller and Zavaleta (2009) tallied the most common recommendations for protecting biodiversity under changing climates: (1) increase connectivity, (2) integrate climate change into planning, (3) study the responses of species to climate change, (4) translocate species, and (5) practice intensive management to secure populations. The purpose of asking questions about feasible actions versus actual actions was twofold: responses provide specific examples that can be compared to the definitions of adaptation and represent a snapshot of the current distance between what actions are currently envisioned and what is under way.

Context for Adaptation: Climate Change in the Great Lakes Region

Stakeholders' perceptions of climate change adaptation in the Great Lakes region are most informative when viewed in the appropriate context: observed and projected changes in climate in the region. Global climate change is already contributing to at least five types of changes in the region: (1) increased air and summer surface-water temperatures, (2) longer growing seasons and a longer stratified period in the Great Lakes, (3) changes in the direction and strength of wind and water currents in the upper Great Lakes, (4) flashier precipitation (increases in storms intensity and drier periods in between), and (5) decreased ice cover on

the Great Lakes (Austin and Colman, 2007, 2008; Desai et al., 2009; Dobiesz and Lester, 2009; Hayhoe et al., 2010; Thomas, Melillo, and Peterson, 2009; Wang et al., 2011). As increases in global temperature accelerate, we can expect the pace of many, if not all, of these current trends to increase, as well, and can expect higher variability and more extremes in precipitation-related impacts (Mishra, Cherkauer, and Shukla, 2010; Trenberth, 2011), which are likely to contribute to a wider range of variation in Great Lakes water levels (Gronewald et al., 2013; Lofgren, Hunter, and Wilbarger, 2011). All of these factors act as important drivers of ecological processes in lake and coastal systems, and many can limit the suitability of the region for species that are of conservation interest (Hall and Root, 2012). Impacts like increases in temperature and increases in run-off from peak rain events also are likely to increase the threat associated with current stressors (e.g., invasive species that may be currently limited by colder water or water depth, algal blooms). Further, these factors often interact with one another, complicating our ability to anticipate climate change trends and impacts and to develop effective adaptation strategies.

Methods

Sampling Frame

To conduct our survey of the resource management community in the Great Lakes region, we built upon participant lists from conservation planning and strategy development efforts led by The Nature Conservancy, with contributions from many partners. These efforts are described in conservation plans, known as the *biodiversity conservation blueprints* (Pearsall et al., 2013) that were developed for Lakes Ontario (Lake Ontario Biodiversity Strategy Working Group, 2009), Huron (Franks Taylor et al., 2010), Erie (Pearsall et al., 2012a), and Michigan (Pearsall et al., 2012b). These biodiversity blueprints aim to facilitate coordination of conservation activities among multiple stakeholders by assessing the current status of, and challenges to, biodiversity (e.g., invasive species, coastal development, impacts of run-off from agricultural or urban land uses) and by developing a comprehensive set of conservation strategies to address key challenges. In general, the geographic scope of the conservation plans includes the lakes and the immediate coastal area (roughly 2 km inland from the shoreline). While the goals for protection and restoration focus on ecosystem types and important ecological processes that occur within this 2-km boundary around each lake, the spatial context for conservation strategies often extends further into the Great Lakes watershed, as many key threats to the system arise within nearby systems. Additional details on the methods of the conservation blueprints can be found in Pearsall at al. (2013).

In the development of the biodiversity blueprints, the planning teams assembled teams of stakeholders from multiple agencies and organizations that were in some way involved in management of the focal ecosystems (Pearsall et al., 2013). These stakeholders represented nongovernmental organizations engaged in conservation; federal, state and local land and water management agencies; academic and research institutions; and private-sector organizations that use or manage key resources. Stakeholders engaged in creating the biodiversity blueprints numbered at least 250 per each of the four lakes, for a total of over 1,100 individuals. These stakeholders represented the sampling population of our survey.

Survey Instrument and Deployment

The electronic survey was divided into five sections: (1) The extent to which climate change was relevant to the field of work, (2) perceptions of climate change and potential impacts on the Great Lakes region, (3) responses to the effects of climate change, (4) current and potential actions or policies for addressing climate change, and (5) demographic information. The survey included both closed questions (yes/no, multiple choice, ranking) and open-ended questions. So as not to influence respondents' definition of adaptation, we did not include a definition of this term.

We created a wide range of survey questions in each section and then worked with the Office of Survey Research (OSR) at Michigan State University, who revised the survey and created an online interface and linked database. We sent early versions to colleagues, as well as to individuals with expertise in survey methods, for feedback. After further refinement based on critical review and test runs with practitioners, we finalized the Web-based survey, and the OSR sent a link to a list of 1,140 e-mail addresses. Prior to sending the Web link, the OSR e-mailed each person a letter that provided information on the goals of the study, a notice of when they could expect to receive the link to the survey, and our contact information. The OSR sent the survey link on November 14, 2011, which was followed by up to three reminder e-mails to those who had not responded in November and December. They closed the survey in January 2012. A total of 411 respondents partici-

pated in the survey (a 39.4% response rate), though not all participants who started the survey completed all questions. The full survey is available by contacting the authors.

Coding of Open-Ended Questions

This article reports on several open-ended questions that aimed to assess the respondents' perception of climate change adaptation. To summarize these highly variable responses, we worked as a team to develop codes and classification schemes. In the "Responding to the effects of climate change" section, we asked respondents "Please describe what the term climate change adaptation means to you" (hereafter, *adaptation definitions*). In this section, we also asked them to list up to three examples of "feasible" climate change adaptation actions. Similarly, in the "Current and potential actions or policies for addressing climate" section, we asked respondents to list up to three actions that they were currently taking that they identified as climate change adaptation. We refer to these as "actual" changes or as actions that are "under way."

To describe the range of adaptation definitions, we (all four authors) coded the adaptation definitions collectively by consensus, using an iterative process to develop our final set of definition types. Our process involved all authors reading all definitions prior to defining the types, and reviewing the IPCC's 2001 definition and other recent definitions (Table 1) to inform our discussions (McCarthy et al., 2001). We chose the IPCC definition as a benchmark because it emerged from an extensive, consensus-driven process, is widely cited, and includes several distinct components that could be used to characterize answers. Specifically, the IPCC definition identifies both human and natural systems as benefactors of adaptation actions, highlights goals of reducing risks and taking advantage of benefits, and recognizes a role for a wide range of anticipatory and reactive responses, including a mention of evolutionary adaptation.

After individually reading through the full list of responses, we first grouped them into three categories: adaptation, vaguely adaptive, and not adaptation (Table 2). At this and later stages of the classification development, each author assigned the responses to categories, and we then compared codes for each response to resolve differences and to clarify factors that best defined each category. Responses grouped under adaptation broadly corresponded with the basic premise of the IPCC definition; they included mention of "responding to climate impacts," "changing management," "enhancing resilience," "reducing vulnerability," or similar concepts. A key identifier of answers in the adaptation category was some indication of intentional action or response to impacts (observed or future). Answers that we coded as vaguely adaptive tended to be vague, passive, and often gave circular definitions (e.g., used the word "adaptation" to describe adaptation) (Table 2). "Not adaptation" responses were oriented toward species evolution, climate change mitigation, lists of climate change impacts, "don't know," or unintelligible answers.

Within the group of answers that described a response to climate change impacts (adaptation), one of the most notable differences among answers was the presence or absence of a proactive/anticipatory component (Table 2). Responses we classified as proactive included the idea of planning for future change or using climate change projections or scenarios to inform actions; they were either entirely proactive or included both proactive and reactive components. Reactive responses failed to include any mention of anticipatory planning or preparing for change and focused on reacting to changes after they became apparent. We chose to use this characteristic as the next level in our classification because it provided a relatively even split of the adaptation answers and represented a meaningful difference with respect to informing future outreach efforts.

In the proactive category, we classed responses into comprehensive, specific, and general based on the level of detail and depth of concept included in the definition (Table 2). In addition to describing anticipatory action, proactive-comprehensive answers addressed multiple aspects of adaptation. For example, they might have included both people and nature as beneficiaries, addressed the need to address uncertainty, and described broad action steps, like updating management practices and goals. Proactive-specific answers were again anticipatory but did not include as many components as comprehensive answers; they often included system-specific examples or listed specific management sectors for which the concept was particularly relevant. Proactive-general answers were typically short and simple, conveying the intent of actively responding to change without illustrating components of the process or examples.

Within the reactive category, we grouped responses into general or specific answers but did not have a "comprehensive" option. We felt that answers could not be considered comprehensive with respect to the IPCC and other

Table 2. Response-type characteristics and examples of survey participants' answers to "Please describe what the term climate change adaptation means to you"[a]

Response type and description	Examples
Adaptation	*Climate change adaptation* means factoring what we know about climate change into our planning and implementation. It means accepting uncertainties and anticipating what the world may be like in the future rather than solely trying to maintain past conditions. It means not only identifying how to respond to direct changes in climatic factors (e.g., changes in Northwoods snow depth) but also the indirect implications of those changes (e.g., what that means for herbivory and forest regeneration).
Proactive, comprehensive	Including the best available climate change trends and predictions in management planning and decision making to ensure that natural ecosystems and people can survive and thrive under projected future conditions.
Anticipatory, may also identify some reactive components	
Multiple aspects—e.g., addresses uncertainty and risk; includes people and nature, direct and indirect effects, and/or the concept of updating goals	
Proactive, specific	How we and other species are going to adapt as climate change progresses. For instance, adapting to more intense precipitation events by designing and retrofitting green and gray infrastructure (including stream systems) to accommodate flows from more intense rain events, which tend to generate more surface run-off. May also have to adapt our models for flood risk.
Anticipatory; may also identify some reactive components	
Often a single detailed example that suggests an adaptation strategy for a particular impact	
Some identify multiple sectors	
Proactive, general	Identifying and preparing for potential climate change impacts.
Simple, forward-looking definition without examples	
Reactive, specific	Any behavioral, management, distribution, or infrastructure changes made by humans or animals to survive or maintain the same quality of life under changing climate conditions.
Only reactive, not anticipatory	Adjusting management, operation procedures, and/or infrastructure to accommodate changes in ecosystem services as a result of climate change.
Often identify multiple sectors or provide examples of actions	
Often incorporate adaptation of species in a way that is consistent with evolutionary definitions of adaptation	
Reactive, general	The process needed to adjust to changes in the environment as the effects of climate change occur.
A simple definition that is not proactive and does not provide examples	
Vaguely adaptive	Adapting everyday life to results of changes in the climate.
Typically use *adaptation* or *adapting* in the definition	Changing the way we deal with things.
Not climate change adaptation	*Evolutionary adaptation:* A species must adapt to the changes in climate in order to survive under the new climate conditions.
Several types	*Mitigation:* Slowing the rate of change to allow species, science, and technology enough time to manage the new environment.
Largest group includes definitions that focus on wild species and resemble adaptation in an evolutionary context	*No definition:* The word *adaptation* says it all.

[a] See Figure 1 for percentages of responses that were categorized as each type.

well-accepted definitions if they did not include the idea of preparing for future changes in addition to responding to observed impacts.

The second and third open-ended questions considered in this report focused on feasible or actual adaptation actions. To categorize actions, we again used a consensus-based (involving three of the four authors), iterative approach to first assign actions to broad categories, followed by a step of reviewing codes as a group and resolving differences and then subdividing responses within categories and repeating the process. Our classification builds from a system used by Poiani et al. (2010) to describe climate adaptation actions identified by 20 teams of practitioners engaged in a comprehensive process for updating current conservation strategies. Poiani et al.'s system was created by modifying a typology from Salafsky et al. (2008) for describing conservation actions.

A first key difference between the work by Poiani et al. (2010) and ours is the nature of the information we were classifying: they looked at sets of actions developed through an intensive process of research and peer-review, whereas our survey results represent a quick snapshot of ideas from respondents with a wide range of experience in thinking about adaptation. Some responses in our survey, like the strategy updates described by Poiani et al. (2010), clearly linked the action with reducing climate-related threats (or taking advantage of a new climate-related opportunity), but most did not. In our coding, we did not attempt to determine whether a response qualified as adaptation; rather, we grouped the responses by the type of action described, with the intent of conveying the range of topical areas that were mentioned.

A second important difference between the responses we coded and those described by Poiani et al. (2010) is that we did not limit respondents to conservation-related actions, and many provided examples that were focused on infrastructure, public health, or "conserve water," an answer that we could not specifically associate with resource conservation, public health, or infrastructure, so we made a new category. Thus, our classification goes into much more detail for natural resource management types of answers (categories 0–7 in Table 3) than for adaptation actions in the context of infrastructure or public health (1 category each in Table 3). Finally, some respondents described climate change mitigation actions (e.g., reduce use of fossil fuels, use compact fluorescent lightbulbs) rather than adaptation actions. Climate change mitigation actions were put in a separate category: mitigation-related policy actions were counted within this category rather than under law and policy (category 5 in Table 3). We also added a few subcategories to the classification to reflect region-specific responses (e.g., subcategories 1.2 and 2.5, which deal with changes in Great Lakes water levels). In areas of the classification that are highly relevant to resource management and for which we received many responses (e.g., science and planning, land/water management), we developed a third level of categories to describe more fully the topics covered (e.g., to capture specific ideas like increasing connectivity); results at this higher level of detail are available from the authors.

Data Analysis

The OSR team detailed the responses for the closed-ended questions, providing numbers and percentages of survey participants who answered each question, counts for each answer, and descriptive statistics of the answers, when appropriate. To summarize patterns in the responses to our requests for feasible and actual actions, we developed histograms showing responses at the highest level of our classification hierarchy. To test whether the distribution of actions across the various categories differed between the set of feasible and actual actions, we performed a goodness-of-fit test. Since a goodness of fit is an observed-expected test, and we had different numbers of responses for the two questions, we first calculated the proportion of actions that were classified into each high-level category (0–12) for the feasible actions. We multiplied each proportion by the total number of actual actions to develop an expected distribution for the actual actions and calculated the chi-squared value based on these observed and expected values.

As all of the responses from the same person were tagged with that user's unique numeric identifier, we were able to link answers from different questions to look for patterns. To examine tendencies of respondents with different types of definitions of climate change adaptation to also provide examples of adaptation actions, we calculated the percentage of respondents within each definition group (including the group of respondents who did not provide a definition) who gave at least one example of an adaptation action (feasible or actual). Similarly, we tallied the counts of actions of each type (based on the classification in Table 3) by adaptation definition group.

Results

Demographics

Most respondents worked as natural resource managers or conservation practitioners (65%); other common sectors included water management (12%), academic or agency research (12%), and planning and zoning (5.2%). A diverse range of sectors were represented by a few individuals (public health, agriculture, energy, transportation, etc.). Many were employed by state, federal, or provincial government agencies (55%); other employers included nongovernmental organizations (23%), local or county government agencies (5.1%), tribal government agencies (2.2%), Canadian conservation authorities (7.4%), academic institutions (8.0%), planning commissions (3.7%), and the private sector (3.1%). Most respondents were based in Michigan (38%) and Ontario (28%). Other home states included New York (8.4%), Wisconsin (7.5%), Ohio (6.5%), Illinois (6.2%), Indiana (3.7%), Minnesota (0.9%), and Pennsylvania (0.9%). This sample of Great Lakes resource managers and conservation

Table 3. Taxonomy for classification of feasible and actual climate change adaptation actions reported by survey respondents[a]

Taxonomy of adaptation strategy actions	Feasible		Actual	
0. Science and planning	0	**87**	4	**106**
0.1. Scientific research	31		54	
0.2. Conservation planning	31		14	
0.3. Monitoring	24		21	
0.4. Planning for extreme events (e.g., drought)	1		13	
1. Land/water protection	13	**22**	11	**12**
1.1. Protect a system (e.g., purchase for conservation)	8		1	
1.2. Protect a system exposed to changing water levels	1		0	
2. Land/water management	3	**174**	26	**82**
2.1. Manage natural sites/areas	3		0	
2.2. Control invasive/problematic species	11		10	
2.3. Restore habitat and natural processes	111		33	
2.4. Manage working lands (e.g., forestry, agriculture)	42		11	
2.5. Adjust water use in response to lake-level decline	1		2	
2.6. Reduce stressors from energy development	3		0	
3. Species management	0	**28**	10	**15**
3.1. Manage existing populations	10		5	
3.2. Species recovery	16		0	
3.3. Ex situ conservation	2		0	
4. Education and increasing awareness	1	**13**	37	**37**
4.1. Professional training	3		0	
4.2. Communications—general outreach	9		0	
5. Law and policy	2	**41**	15	**15**
5.1. Legislation (create, promote)	1		0	
5.2. Policies and regulations (implement)	33		0	
5.3. Private sector standards and codes	5		0	
6. Livelihoods, economics, and incentives to influence behavior	6	**12**	3	**5**
6.1. Promote local businesses, seize new opportunities	3		0	
6.2. Substitution (e.g., promote the use of an abundant resource instead of a rare one)	1		0	
6.3. Market forces (e.g., forest certification)	1		2	
6.4. Conservation payments	1		0	
7. External capacity building	0	**3**	17	**17**
7.1. Institutional and civil society development	1		0	
7.2. Alliance and partnership development	2		0	
8. Infrastructure management (community/municipal)	4	**125**	8	**14**
8.1. Site/area management	31		0	
8.2. Storm-water and flood management	46		2	
8.3. Green infrastructure implementation	27		4	
8.4. Green infrastructure planning	17		0	
9. Human health and safety	0	**17**	7	**8**
9.1. Emergency planning, capacity, and response	8		1	
9.2. Disease risk	1		0	
9.3. Relocation of people (e.g., in floodplains)	3		0	
9.4. Other health issues	5		0	
10. Reduce water use by people (conserve water)	12	**12**	0	**0**
11. Climate change mitigation	6	**43**	38	**39**
11.1. Policy	2		0	
11.2. Change the form of energy/support green energy	16		0	
11.3. Sequester carbon	3		0	
11.4. Reduce energy use/increase efficiency	9		1	
11.5. Reduce emissions	7		0	
12. Unclear	8	**8**	9	**9**

[a] Numbers of feasible and actual actions are listed in the two columns on the right. *Bold numbers* represent the total number of actions for each category; this is a sum of responses from the subcategories under that category, and answers (aligned with the category) that were too general to be assigned to subcategories.

practitioners was 64% male, 94% white, and highly educated; 94% held a bachelor's or higher degree, 41% a master's degree, and 28% a doctorate.

Context for Adaptation: Climate Change and Work

Most participants (72%) reported that discussions of climate change at work have increased compared to five years ago, and half (51%) stated that climate change has led their organization to reassess its mission, goals, and strategies. At the time of the survey, most (77%) of participants spent less than a quarter of their time doing climate change–related work: this included 15% of participants who spent no time on climate change. Yet, 38% stated that climate change is highly relevant to their work. A much larger group, 82%, said they consider climate change in their current or future work, though only 24% said they had "sufficient information to address climate change." Half (51%) stated that they currently take actions that they would deem climate change adaptation, and 73% said they were aware of other organizations taking actions to address climate change.

Perceptions of Climate Change and Potential Impacts

An overwhelming majority of respondents (90%) indicated that a changing climate had already affected the Great Lakes region, with 39% indicating it had affected the region "a lot" and half suggesting that climate change had affected the region "a little." Only 1.3% suggested that climate change had affected the region "not at all." When asked to look 50 years into the future, 28% said that climate change will "profoundly" affect the region and 51% said it would affect the region "a lot," whereas a minority said climate change would affect the Great Lakes region "a little" (11.3%) or "not at all" (1.8%).

As examples of how respondents perceived the impacts of climate change on biodiversity and resource management in the region, 65% indicated that climate change would "likely increase" the number of native species showing population declines, and 85% foresee climate change "likely increasing" costs for controlling nonnative invasive species. Similarly, 76% expected to see costs for controlling forest and farm pests and weeds increase, and 75% anticipated increases in costs to home owners because of flooding. Most also expected the Great Lakes region to experience increases in heat wave–related human deaths (65%) and an increased frequency of beach closures (67%). About one third (31%) of respondents felt that the approaches needed to address climate change impacts in the region are "fundamentally different" than current natural resource management approaches, whereas 55% said they differ only "slightly or marginally" from current approaches, and 14% said they do not differ at all.

Definitions of Climate Change Adaptation

Asked to what extent *climate change adaptation* represents a clear term, 19% responded that the term is completely clear, 57% said somewhat clear, 20% said unclear, and 3.8% were unfamiliar with the term. Of the 74% of survey participants who answered the open-ended question "what does climate change adaptation mean to you," nearly three quarters gave a description that, in a general sense, conveyed the idea of responding to climate change impacts and thus corresponded with commonly cited definitions (Figure 1). Within this adaptation subset, proactive definitions were more common than purely reactive definitions, though definitions in both sets varied in depth and detail (Figure 1). Although we classified descriptions that focused solely on mitigation or evolutionary ideas as not adaptation, many definitions that we grouped under adaptation included statements about mitigation, or included examples of evolutionary adaptation (or lists of impacts or snippets of political commentary) in addition to describing intentional response to climate change impacts and risks.

When asked whether they could identify feasible climate change actions, 71% of respondents said they could. The group that responded positively were asked to provide examples of up to three actions, and 55% of the total number of participants provided at least one example. Of the 585 feasible actions described, most fell under the categories of land and water management (30%), infrastructure management (21%), and science and planning (15%) (Figure 2). The most common answers ($N = 359$ actions, with 39% responding) to a request for up to three "actions that you are currently taking" included actions we classified as science and planning (30%), land and water management (23%), and education and increasing awareness (10%) (Figure 2). Climate mitigation–related answers (e.g., conserve energy) were also common in the actual action responses (11%). We found a significant difference between the distribution of feasible and actual actions across the action type categories ($\chi^2 = 362.0$, $p < 0.0001$). Relative to the feasible actions, the distribution of actual actions suggests a shift toward science and planning, education and increasing awareness, and capacity building, with a reduction in the proportion of actions that fall under of land

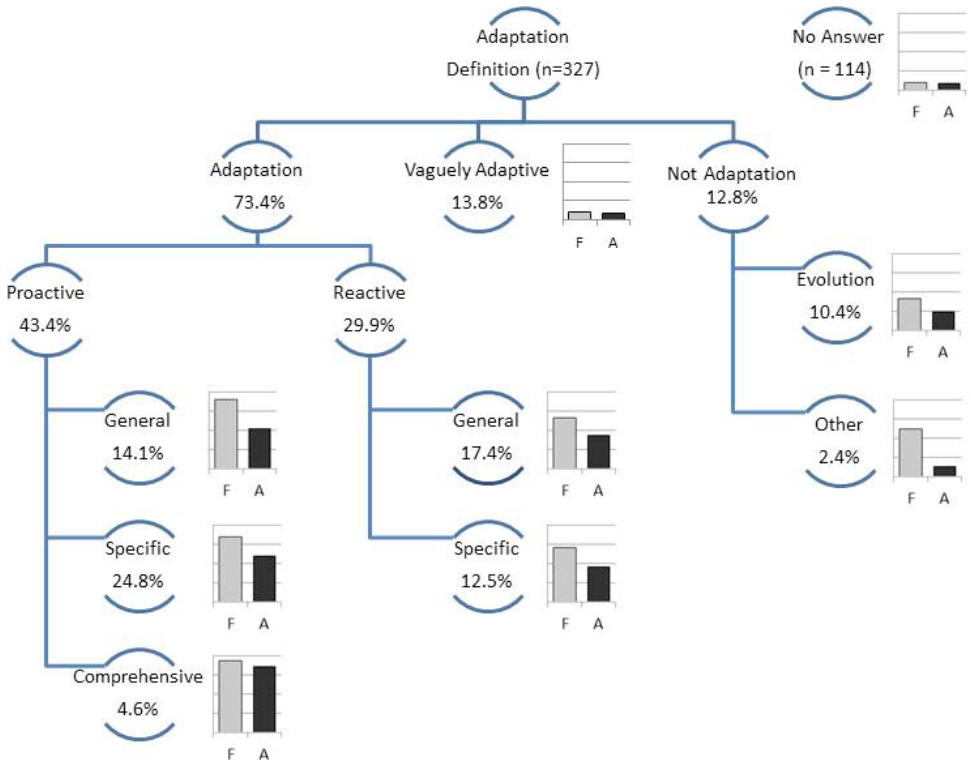

Figure 1. Classification of definitions of *climate change adaptation* provided by participants in a survey of professionals engaged in Great Lakes conservation planning efforts. All percentages shown are in reference to the total number of respondents who chose to provide definitions ($N = 327$). The *bar graphs* next to each of the lowest levels in the categorization show the proportion of respondents (the horizontal axis goes from 0 to 100% for all graphs) with definitions in each category that provided at least one answer to the request for "feasible" (F) or "actual" (A) actions.

and water management, and a large drop in the proportion of actions related to infrastructure management (Figure 2). These results appear to indicate that many respondents are in the early planning and education stage of adapting to climate change, as opposed to actually implementing management actions. It is also likely that while the need to update infrastructure, especially infrastructure related to handling storm water, is well recognized in the region, only a small proportion of the respondents we surveyed would be in a position to be directly involved in actual actions in that sector.

We expected that respondents who provided a definition that, at a minimum, indicated responding to climate change would be more likely to provide examples of actions than those with vague or nonadaptation definitions or no definition. To consider the relationship between definitions and actions, we examined patterns across both sets of results. Specifically, we calculated the percentage of respondents in each group who provided at least one example of a feasible, and an actual, adaptation action (Figure 1 bar graphs). Respondents who provided definitions that we categorized as adaptation were more likely to also provide examples of actions, and the group of people with proactive definitions appeared most likely to provide examples. Only about 10%–15% of people with vaguely adaptive definitions, or who did not respond to the definition question, provided examples of actions (Figure 1 bar graphs). Similarly, we plotted the distribution of action types by the separate adaptation definition groups, but these distributions largely mirrored the overall distribution for actual and feasible actions, so are not included here.

Discussion

We asked resource managers and partners who contribute to conservation planning in the Great Lakes region to

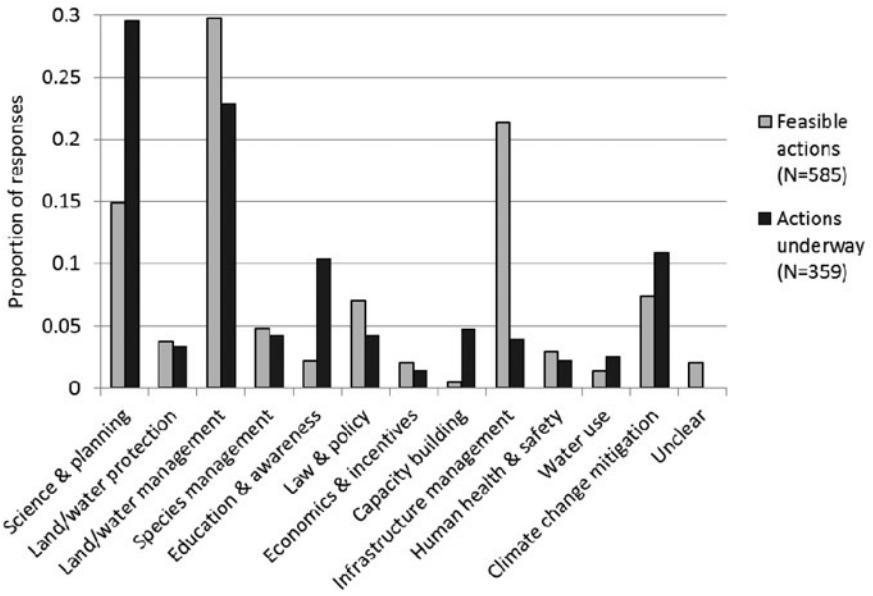

Figure 2. Distribution of types of actions described by survey respondents in response to requests for examples of "feasible adaptation actions" (*gray bars*), and adaptation actions that respondents are currently taking (*black bars*). Types of actions are defined in more detail in Table 3.

provide, in their own words, definitions and examples of climate change adaptation. In a general sense, some results are encouraging—as Bierbaum et al.'s (2013) review suggests, progress is being made, as evidenced by most respondents understanding the importance of considering climate change impacts, and many feel they can provide a definition of this still somewhat novel term. These results and others from our survey are consistent with the idea that addressing climate change has taken on greater importance for those we surveyed in recent years. Great Lakes resource managers and conservation planners report discussing climate change more at work, indicating that this threat has emerged as an important factor in natural resource management.

However, in reviewing both the definitions and example actions, we see clear indications that those interested in engaging stakeholders could play an important role in increasing the region's collective ability to reduce risks to people and nature. Specifically, we see a great need for helping groups clarify the concept of climate change adaptation and for outreach that targets the need to build support for strongly proactive approaches. The growing literature on climate change adaptation has identified the need to take a proactive approach, especially in the context of protecting species and ecological systems already at risk (Bardsley and Sweeney, 2010; Baron et al., 2009; Lawler, 2009; Poiani et al., 2010; West et al., 2009). Being proactive entails identifying climate change as a significant threat, indicating consequences it would likely have, and identifying specifically how to address those threats through a set of actions designed to reduce future risks. Although our survey was not designed to elucidate this level of detail from respondents, in reviewing the full range of adaption definitions and examples of actions we find that most resource managers in the Great Lakes have not yet conceptualized adaptation in such a directed, proactive manner.

Although our results suggest that nearly three quarters of adaptation definitions communicated the basic premise of commonly cited definitions, our coding was quite generous, and many descriptions in our sample included additional concepts within the responses. Most importantly, few definitions clearly communicated what we see as the essential idea of climate change adaptation: taking anticipatory action to reduce risks to people and nature from climate change impacts.

Some of this confusion and lack of clarity is to be expected because climate change adaptation is still a new idea for many. However, we also suggest that if outreach efforts use the broad IPCC definition (Table 1), which includes a range of passive, reactive, and active approaches, the complexity

and breadth of the definition may contribute to this confusion. Further, the IPCC adaptation definition suggests that adaptation can come about through reactive or proactive means, but also states that "biological adaptation is reactive . . . , whereas individuals and societies adapt to both observed and expected climate through anticipatory and reactive actions" (p. 720). This inclusion of biological (or evolutionary) adaptation within definitions of climate change adaptation is common. The key point here is one of knowing your audience when you choose a definition to work from: Although multifaceted definitions of climate change adaptation like the IPCC definition broadly emphasize intentional action (reactive or anticipatory) to reduce risks, practitioners trained in evolutionary concepts may feel they understand adaptation but may not internalize this emphasis on intentional action, given that evolutionary adaptation is a passive process (species do not "intend" to evolve). Potentially, this framing contributes to a reduced sense of urgency and undermines our call to action—and this is likely why Hansen and Hoffman (2011) (see Table 1) exclude evolutionary adaptation in the definition they provide in their recent book on adaptation guidance for resource managers.

In addition to lack of conceptual clarity, we found that many people described adaptation primarily as a reactive, rather than anticipatory, process. There are many possible explanations for reaction-focused or even passive definitions of adaptation. For example, perhaps respondents cannot perceive of ways to initiate adaptive actions before knowing how climate change will affect the region. This seems plausible for some, given the often highlighted uncertainty about climate science and projected impacts. Perhaps even more simply, some of the reactive answers may be linked to the concept of adaptation remaining unclear and thus difficult to articulate except in a context in which actions are proposed to address an existing, rather than future, problem. In essence, both of these rationales argue for the idea that definitions matter and that, to promote proactive action on climate change adaptation, an important first step is working with stakeholders to evaluate and clarify the definition.

For those engaged in developing guidance for, or working with, stakeholders to promote adaptation, we suggest other starting points besides the IPCC or similarly all-inclusive definitions. As with many general ideas that need to be applied at local levels, the most useful definition may depend on the goal of the guidance or outreach effort. The short definition from Hansen and Hoffman (2011)—"human efforts to reduce the negative effects of or respond to climate change" (p. 2)—is a good starting point; pieces could be added to provide detail and communicate perspective, such as the group's view on the importance of proactive solutions, and the need for transformation in key areas of practice or policy [e.g., definitions by Moser and Ekstrom (2010) and Doria et al. (2009); see Table 1].

Climate Change Adaptation Actions

The responses to the requests for feasible and ongoing climate change adaptation actions were again encouraging: More than half of the respondents said they could identify feasible actions, and many were able to provide examples. On the positive side, the range of feasible ideas presented suggests that the Great Lakes resource management community is thinking about many kinds of vulnerabilities—from species and ecosystems to public health and safety. They are also considering the potential for failing infrastructure and how *green solutions* (e.g., restoring wetlands near rivers to help reduce flooding) can help keep people safe. However, the examples presented still suggest that the pace of implementation is slow, and likely "less than needed" (Bierbaum et al., 2013). Fewer survey participants (39%) gave examples of adaptation actions that they are engaged in, and these were biased toward the early stages of adaptation: science and planning, education and outreach, and capacity building.

While many respondents provided examples of actions, it is important to note that the ideas presented were often vague and consistent with conservation-as-usual types of actions (e.g., protect biodiversity, restore connectivity, control invasive species). A few respondents were more specific, providing examples that illustrated a key process that we consider a sign of a more advanced understanding of adaptation: linking the action to reducing risks attributable to a particular climate-related driver. Examples included suggestions to restore riparian forests to shade streams and to protect fish from warming water temperatures, and actions that involve identifying and protecting pathways for coastal wetlands to "migrate" in response to changing Great Lakes water levels. Interestingly, the more adaptive answers often addressed water management and coastal infrastructure (e.g., design coastal infrastructure to be viable under a range of water levels, increase riparian vegetation buffers to prevent flooding), suggesting that outreach and actions in these sectors may be ahead of work in other sectors, such as wildlife management, and could serve as good examples for other efforts.

Climate Change Perceptions and Using What We Have Learned

The broad agreement emerging from the survey indicated that most respondents view climate change as inevitable and associate observed and projected changes with a wide range of impacts on ecological and social values. In general, participants seemed well aware of observed and projected trends—for example, air temperatures, heat waves, and growing season lengths were widely viewed as likely to increase in the future, whereas participants noted high uncertainty in expectations for precipitation. Most respondents also had consistent views on natural resource impacts, such as how climate change will affect native species and invasive species. However, only a minority thought that climate change would profoundly affect the region in the future. This mismatch is telling and likely helps explain the lack of proactive ideas in many answers and the lack of agreement in the need for transformations within the natural resource sector to address climate change. While not addressed in our survey, some of this apparent lack of urgency in addressing climate change may relate to the Great Lakes region's long history of massive environmental impacts [e.g., land conversion, exotic species invasion, pollution that led to the Cuyahoga River catching on fire (Allan et al., 2013)], and many practitioners may already be overwhelmed by impacts they already see. Based on our results, and our experience in the region, we suggest that outreach activities, guidance, and tools will be best received, and most effective, if they emphasize addressing climate change impacts within the context of addressing current stressors rather than as a stand-alone process.

Importantly, a smaller but still important proportion of respondents did not share the majority views on likely impacts, indicating that outreach efforts should continue to recognize a range of opinions regarding the basic premise of human-induced climate change. To tailor outreach on the need for proactive adaptation to diverse audiences, we can learn from The "Global Warming's Six Americas" work (Akerlof and Maibach, 2011; Leiserowitz et al., 2011; Maibach et al., 2011), which focuses on using audience-segmentation approaches to build support for mitigation efforts. By using the categories from this work, we suspect that our survey may present an overly optimistic picture of current perceptions of the need to act, as those toward the alarmed or concerned end of the Six America's spectrum seem more likely to answer a detailed survey on climate change than those best described by other categories (e.g., cautious, disengaged, doubtful, dismissive). As with mitigation, it is likely that researchers and tool creators in the field of climate change adaptation can better support regional adaptation efforts if they understand the values and perceptions of the various stakeholders within their focal audience and develop approaches that meet current needs (Hansen and Hoffman, 2011; Moser and Ekstrom, 2010). Although people who are ready to take action may be more common among the set of partners engaged in conservation than in broader samples of the public, we need to be careful to develop outreach materials and rationales for adaptation strategies that can meaningfully and effectively engage participants with other views and that can be communicated to broader audiences to support collaborative decision making.

Connecting Outreach on Adaptation to Increased Support for Emission Reductions

In the absence of reductions in the greenhouse-gas emissions that cause climate change, adaptation represents a losing proposition. We suggest that investing in efforts to assess and plan for changes in the natural resource sector can help promote both adaptation and the reduction of emissions, and that resource managers can be compelling messengers to a broader set of Great Lakes residents on the need for climate action. First, leaders of workshops designed to help communities prepare for climate change impacts in the western United States report that, for many participants, the process of thinking through climate risks and potential adaptation actions increases their interest in, and sense of urgency about, reducing emissions of greenhouse gases (Koopman, 2011; The Resources Innovation Group, 2011). While there are likely many reasons for these changes in mind-set, we expect that shifting the focus from the often politically charged concepts of climate change toward local impacts and how to protect people and nature in their own community helps bring home the consequences of inaction. We expect that similar outreach efforts in the region are helping provide opportunities for natural resource practitioners in the Great Lakes region who may have dismissed the need for climate action to reconsider. Preworkshop and postworkshop survey questions that address willingness to support emission reductions can help workshop organizers evaluate these connections and help us take advantage of this opportunity to progress on both fronts.

Second, investing in raising awareness and building capacity to address climate change adaptation among resource managers helps them convey impacts to the broader public. Managers making decisions using information on weather patterns, phenological states of plants or animals, extent or

duration of snow or ice cover, or other climate-related factors like fire risk, seem most likely to observe, and be able to describe consequences for, climate-related changes. Research suggests that when people believe they have observed climate change, they are more likely to perceive that climate change poses a risk (Akerlof et al., 2013; Myers et al., 2013). Drawing upon this group of stakeholders as we seek to promote broad-based action on climate change adaptation and mitigation might be a very useful strategy—those with in-depth knowledge of natural systems and species who feel they have seen (and can vividly describe) climate change impacts are likely to be some of our most effective spokespersons on the need for action on climate change.

Conclusions

In the Great Lakes region, conservation practitioners recognize the threat posed by climate change, but acting on that recognition has not yet led to widespread implementation of adaptation actions. Our results suggest that one contributor to delays may be of a lack of clarity on the concept of adaptation. Whereas many who conduct outreach efforts may be tempted to use existing definitions and leap forward to discussing actions, our results suggest that efforts to develop definitions that groups understand, agree on, and can operationalize will be time well spent. To us, the responses we received also highlight the importance of developing and showcasing adaptation examples and, most importantly, of presenting the logic underlying the examples (e.g., stating "this action reduces risks by . . ."). These kinds of efforts will help create a deeper shared understanding for the rationale behind adaptation, helping stakeholders move beyond identifying climate impacts toward incorporating climate change into planning and taking appropriate actions to reduce risks. Doing so will position the Great Lakes region to better prepare for and respond to the existing and inevitable consequences to come.

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