

ASSESSING NEEDS FOR CLIMATE CHANGE ADAPTATION
IN THE GREAT LAKES REGION:
INTERVIEWS FROM ACROSS THE BASIN

By Dawn Nelson

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Faculty Advisor: Professor James Diana
Co-Advisor: Heather Elmer

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Table of Contents

Abstract	ii
Introduction	1
Climate Impacts	3
Priority Adaptation Needs	4
Natural Resources, Hazards, and Infrastructure	6
An Economy of Recreation	8
Survey Methodology	10
Needs Assessment	10
Interview Sample Description	11
Data Analysis	12
Interview Results	14
Research, Policy, and Planning	14
Education and Training	16
Coordination, Collaboration and Leadership	18
Discussion	22
Concluding Remarks	25
References	26
Conference Presentations	33
Appendix A: Preliminary Data Collection	
Appendix B: Interview Question Set	
Appendix C: Deliverable 1: Interview Results	
Appendix D: Deliverable 2: NOAA Needs Assessment – Final Report	

Abstract

A total of fifteen interviews were conducted across several Great Lakes states and all lake basins, using a grounded theory approach to inform the development of a broader and more comprehensive survey instrument. Professionals working in community planning and natural resource management in the Great Lakes region have similar information and training needs for climate adaptation in coastal communities. Chief among concerns was the need for improved coordination at all scales and access to local information to address changes in regional climate and management of water quality and quantity.

Introduction

As many people are becoming increasingly aware of the reality of climate change, there has been a strengthening trend over the past decade or so to focus on adapting to the impacts of climate change. In the upper Midwest of the United States, the Great Lakes community has an increasing wealth of literature on impacts to the region, as well as a diverse mix of agencies and groups taking different actions to provide resources to develop the capacity to respond to climate change. The Old Woman Creek National Estuarine Research Reserve in Huron, Ohio is one such entity, the client organization for this project. The Old Woman Creek National Estuarine Research Reserve is part of the National Oceanic and Atmospheric Administration's (NOAA) National Estuarine Research Reserve System (NERRS). The Old Woman Creek National Estuarine Research Reserve is also a designated Ohio State Nature Preserve, making it a unique Federal-State agency partnership and community-accessible, place-based education resource within the Great Lakes basin. In general, the NERRS is a system of twenty-eight research reserves located across the United States that provide the service of developing and implementing resources and trainings to increase local capacity for natural resource management (NOAA/NERRS, n.d.). The overarching goal of this project in particular was to develop training workshops for professionals in the natural resource management field. The first step in the process was to design and implement an assessment to understand the current state of awareness and ability of regional professionals in the field to respond to climate change. Relying on the NOAA Coastal Services Center needs assessment design recommendations (NOAA/CSC, n.d.), I worked in consultation with the client to design a survey instrument that would inform development of subsequent training workshops.

The needs assessment was conducted in two phases, with funding from NOAA Sea Grant for an initial review of existing literature, and funding from the Great Lakes Restoration Initiative for data collection, analysis, and reporting. The initial review of literature and synthesis of existing knowledge on training and information needs was compiled and made available in a technical memorandum (Nelson et al. 2011), informing the needs assessment survey design as well as a related NOAA Sea Grant project, the Climate Ready Great Lakes training modules (Casey et al. 2011). The data collection, analysis, and reporting was coordinated by staff at the Old Woman Creek National Estuarine Research Reserve. This report documents my scope of work within the project, highlighting two key deliverables. First, results of the interview portion of data collection (Appendix C), and second, the final report that synthesized results from the different tiers of data collection for the needs assessment, including interviews, focus groups, and online survey (Nelson, Elmer and Robinson 2013)(Appendix D).

More specifically, the goal of this study was to collect sufficient information about the needs of Great Lakes coastal community planners, stormwater managers, and natural resource managers to design effective training to increase adaptive capacity to climate change. With the target audience in mind, the objective was to assess the following key areas in regard to climate change: current state of awareness, knowledge, and skill; perceptions and attitudes regarding the issue of climate change and how it is connected to community planning, stormwater, and natural resource management; understanding of potential economic impacts; orientation toward adaptive, mitigative, and combined responses; barriers to and benefits of adaptation planning; attitudes toward

planning and decision-making in the face of scientific uncertainty; the need for training and tools; and learning styles and preferred training formats.

Climate Impacts

Annual average temperatures are rising, with a projected increase of 3.6 °F to 5.4 °F (2 °C to 3 °C) average annual air temperature increase by midcentury (Hayhoe et al. 2010). The duration of Great Lakes ice cover is decreasing as air and water temperatures rise (Wang et al. 2012). Additionally, heavy precipitation events are intensifying, resulting in more flooding, runoff, and sediment and nutrient loading impacts (Karl et al. 2009; Lofgren and Gronewold 2014).

Earlier research by Croley (2007) demonstrated four different climate change scenarios as possible for the Great Lakes region: a warmer and dry or warmer and wet climate, or hot and dry or hot and wet climate, which provide for a range of scenarios with precipitation and evaporation being the significant factors affecting Great Lakes water levels. Each of these scenarios indicate a decline in lake levels for the upper Great Lakes, although with some variation in amount, while the only instance of lake levels remaining the same or increasing are the two lower Great Lakes in the warmer and wet scenario (Croley 2007). Furthermore, extreme precipitation events were predicted to increase the need for resilience to higher storm water levels and flooding (Safford et al. 2005). In a report from the Union of Concerned Scientists and Ecological Society of America, shorter winters, warmer annual average temperatures, more frequent extreme heat events, decreased duration of lake ice cover as air and water temperatures rise, and increased in heavy precipitation events were predicted (Kling et al. 2005).

Given such a range of changing conditions, it is important to highlight the need that planners, natural resource practitioners and decision-makers have for local information on climate impacts in order to build adaptive capacity (Mycoo and Gobin 2013).

Priority Adaptation Needs

The National Research Council (NRC) emphasized how to assume strong leadership across the federal government in climate adaptation (NRC 2009). The basis for the full list of recommendations is that “the same core principles that characterize effective decision support in such areas as public health, natural resource management, and environmental risk management apply to informing decisions about responses to climate change” (NRC 2009), and that decision support efforts should be based on users’ needs (NRC 2009).

A user needs assessment for storm surge tools and information was prepared in 2005 for the NOAA Coastal Services Center and emphasized the need for real time monitoring to support an adaptive management framework, because relying on past averages is insufficient for climate planning: “Timely synthesis and analysis of regional ecosystem data will provide managers key information on how environmental conditions are changing and whether new management approaches are warranted” (Safford et al. 2005).

In 2008, the NOAA Great Lakes Environmental Research Laboratory held a climate workshop that delved into issues and needs of six key scientific theme areas: physical environment, water quantity, watershed hydrology, water quality and human health, fish recruitment and productivity, and aquatic invasive species. The summary and

final reports from this workshop included a robust listing of needs grouped under these theme areas, with emphasis on the need for improved data accessibility and model forecasting information for planning (Joseph et al. 2009; Quigley et al. 2009). In 2008, a Climate-Related Needs Assessment Synthesis report from the NOAA Coastal Services Center also listed numerous needs for natural resource management and climate planning, with some key findings indicating the need for hazards information, tools and technical training, along with increased agency coordination and community participatory decision-making (Fauver 2008).

The need for locally-specific information is a common theme for resource management. Desotelle Consulting et al. (2006a, 2006b) identified needs, barriers, and solutions within the basin on both regional and local scales. Leadership, coordination, communication, tools, technical assistance and data access were listed as broader regional needs (Desotelle et al. 2006a, 2006b), while awareness, communication, data sharing and access were listed as local needs (Desotelle et al. 2006a). To emphasize an emerging trend towards ecosystem based management, another report stated that “scientific and social science information needs include matching data collection with management needs, improving access to data, ensuring currency and completeness of data sets, and utilizing GIS and remote sensing technology. Furthermore, managers require appropriate tools and resources to better understand, apply, and communicate the data available. The most prominent type of information needed is information on the human dimensions of ecosystems” (MRAG Americas 2009).

Ecosystem based management has been developed in response to the need for large-scale solutions that address both natural and human systems. “Ecosystem based

management accounts for both ecological and socio-economic factors as well as their cumulative impacts on a management area. Ecosystem based management provides for geographically specific, holistic resource management of habitats, species, and ecosystem level effects of resource use, such as food web impacts” (MRAG Americas 2009). Since such a management approach is inherently transboundary, so stakeholder engagement strategies are also needed (Joseph et al. 2009; Quigley et al. 2009).

Furthermore, lack of integrating field educators in developing relevant applied research projects has been identified as a factor hindering the ability of agencies, such as the Sea Grant Network Extensions, to meet coastal community needs (National Sea Grant Network 2008).

Natural Resources, Hazards, and Infrastructure

Wisconsin’s top natural hazards are “flooding, tornadoes, straight-line winds, and coastal erosion. All fifteen coastal counties in Wisconsin experience erosion, flooding and damage to shoreline structures.... Coastal erosion is a naturally occurring process that can accelerate during strong storms with high winds or heavy wave actions. Such events can cause sudden failure of bluffs" (Wisconsin Coastal Management Program 2006), which has created economic consequences in property damages and implications for land use, planning and development in coastal areas, especially if there is a reliance on past averages for lake levels (Wisconsin Coastal Management Program 2006). The Wisconsin assessment lists the general need for tools, including mapping, GIS, and tracking of hazard areas (Wisconsin Coastal Management Program 2006).

Lichtkoppler and Archer (2007) indicated in the Lake Erie Shoreline Erosion Management Plan Local Community Needs Assessment that property owners would like basic training in controlling shoreline erosion, but there was a level of mistrust of sources for information and data. In this assessment needs are categorized within the framework of plans and permits, financing, best management practices, and understanding Lake Erie erosion. Several key themes emerged in this study when recruiting for focus groups. First, eliciting response for participation was initially poor because people believed the study to be a telemarketing scheme. As the research team asserted their university affiliation, the response changed and became more positive as they were able to establish a level of trust. Second, some property owners did not trust the Department of Natural Resources, and refuse to participate in focus groups. Third, shoreline erosion can be a very emotional issue for some citizens, and any distrust of government for information or training will be difficult to counter when implementing any erosion management approach. Shoreline erosion was also a concern for community officials, local agencies, contractors, consultants, and engineers (Lichtkoppler and Archer 2007). Developers were not included in this study.

Water infrastructure in the Great Lakes basin is aging and in poor condition, increasing the risk of waterborne outbreaks of illness and disease (Patz et al. 2008). The American Society of Civil Engineers have rated wastewater infrastructure with a D-, faring the worst over all other forms of infrastructure (American Society of Civil Engineers 2005). As increased precipitation events inundate impervious surfaces and result in extreme amounts of overland runoff, they also stress capacity of combined sewer systems. This will likely decrease water quality. The United States Environmental

Protection Agency (USEPA) issued a report on the impacts of climate change on water infrastructure, calling out the need to address climate change adaptation planning when implementing changes in wastewater infrastructure, as this infrastructure has a life cycle spanning several decades (USEPA 2008a). The 14th Biennial Report on Great Lakes Water Quality recommends that both US and Canadian “economic-stimuli measures now being developed should address wastewater system needs in the Great Lakes basin” (International Joint Commission 2009).

An Economy of Recreation

Tourism as an industry has unique planning needs for seasonal climate and weather information, both at a regional and local scale; and timely accessibility to that information (Huntley 2009). Public beaches and shoreline access sites were inventoried for Wisconsin, demonstrating general use categories for different types of recreation: land, lake, and river based. These vary by season; since warm and cold weather activities have different weather requirements, therefore climate change will affect each of these recreation categories differently (Wisconsin Coastal Management Program 2006). The Wisconsin needs assessment showed an increased demand for coastal boardwalks and trails, parks, public beaches and fishing piers. Additionally, barriers identified for Wisconsin recreation included multiple recreational activities competing for the same funds and resources, changing land uses, ownership, and regulations that reduce recreational opportunities and diminish resource quality. There is a general need for land and estuarine conservation (Wisconsin Coastal Management Program 2006). Although there is still a small body of literature in this area, the general themes discussed for

Wisconsin can be reasonably inferred for other Great Lakes coastal communities. Issues of water quality, waterborne disease, and aging water infrastructure are important throughout the Great Lakes (Great Lakes Beach Association 2005; Patz et al. 2008), and there is need for ecological forecasting to inform tourists and other beach users of beach conditions to maintain public health and safety (Sturtevant 2004). Impacts on the tourism industry will vary depending on region and locality, and tourist preferences for the climate and location of recreational destinations will change, influenced by tourist age and income (Lise and Tol 2002).

Survey Methodology

Needs Assessment

The methodology outlined in the NOAA Coastal Services Center needs assessment online training module was utilized for this study. This methodology is broken down into sections that consist of planning, data collection, and data analysis and reporting (NOAA/CSC, n.d.). In the planning phase, my initial review of literature was summarized in NOAA Technical Memorandum 153 (Nelson et al. 2011). This technical memorandum informed overall development of the survey instrument for the needs assessment, as well as design of the question set for interviews summarized in this report. Additionally, preliminary data collection undertaken by the Old Woman Creek National Estuarine Research Reserve also served to inform design of the interview question set, the results of which are available in Appendix A, and the question set in Appendix B.

A three-tiered approach for data collection was used to identify information and training needs. By relying on this grounded theory approach, it was possible to identify concepts in the interviews that helped to revise questions and analysis in later stages of data collection (Stern and Porr 2011; Oktay 2012). Beginning with in-person and telephone interviews, the information collected in the first and second tiers brought insight to develop a broader survey instrument, refining the calibration of the questions and survey instrument for deployment. The second tier included focus groups, and the third tier was an online survey during January and February in 2011.

Interviews were conducted from July through September 2010. Potential participants for interviews were identified through Ohio Coastal Training Program contact database, the NOAA Sea Grant Extension Agent Network and other NOAA

partners. In-person and telephone interviews were conducted across nearly all of the Great Lakes states, with fifteen interviews completed in August and September of 2010. The subject pool was generally constrained to one coastal county inland, in some cases two, but no more than three counties inland. This facilitated a watershed perspective to identify issues.

Invitations to participate were sent by email in July, with immediate positive responses for both interview and focus group participation. Interviews were estimated to take 30 to 45 minutes, and this proved to be a sufficient amount of time to answer a set of eight questions. Once this method for eliciting interview participation yielded little or no response, recommendations for interview candidates were requested of Sea Grant Extension Agents and other professionals working closely with the needs assessment team, yielding a larger subject pool. These interviews are considered ‘key informant’ interviews.

Interview Sample Description

An interdisciplinary approach was taken in order to gauge what issues might be common across separate yet similar sectors in natural resource management. While the scope of the interview sample was limited to a sample size of fifteen participants, the goal of the interview sample was to inform a broader collection of data. Aside from this limitation, the strength and benefit of the in-depth interviews is the level of detail provided for content analysis. The interview sample is described in Table 1.

Table 1. The number of interviews conducted across the lakes and states in the Great Lakes region.

Lake Basins	States	Professional Roles and Number of Interviews per Role
Ontario	New York	<ul style="list-style-type: none"> • Planners (4) • Watershed managers (2) • Water infrastructure managers (4) • Natural resource managers (3) • Program directors (1 public health, 1 environmental education)
Erie	Ohio, New York, Michigan	
Huron	Michigan	
Michigan	Michigan, Illinois, Wisconsin	
Superior	Minnesota, Wisconsin, Tribe (1)	

Assuming that participants had at least a basic awareness of climate change from popular media, and that the range of awareness could be a broad spectrum from basic to very high literacy, there was a lot of variability when assessing the level of awareness of each interviewed person. Additionally, I anticipated that there could have been some denial that climate is changing.

Data Analysis

Audio-recorded data from interviews and focus groups were transcribed, with partial support from administrative staff at Old Woman Creek National Estuarine Research Reserve. Each interview transcription was then summarized to facilitate synthesis and reporting of the data. Content categories were formed through a coding process that identified the topics mentioned by each participant.

Topics were then tallied and categorized in matrix form. Topics falling under the main headings of the issue categories were counted once per interview. For example, a participant may have talked about a topic extensively, but it was counted only once.

The major issue categories were grouped as discussion areas for research, policy, and planning needs; education and training needs; and coordination, collaboration and leadership. While the interview report in Appendix A shows the top ten issue categories, the following results and discussion list a more detailed analysis upon a second review of interview data. A list of the topics included in each issue category are elaborated in the following section and grouped by the discussion areas described above.

Interview Results

Research, Policy, and Planning

Water management in terms of quantity rose to the top of the list of concerns, with topics under this heading emerging thirty-three separate times across interviews (Table 2). Water from storms, heavy rain, and snow can cause flooding and impact infrastructure, including septic systems and basements. Similarly, water management as an issue of quality (26) included both drinking water and bathing beach quality. Wastewater treatment and the need for treatment plants to be able to perform effectively given increased intensity of precipitation events was also a concern. One natural resource manager also highlighted the need for more research on the effects of atmospheric acids on the lakes, and another spoke of the need for research on the impact of Asian carp on the aquatic food web.

Natural area preservation as a component of ecosystem based management was also mentioned a number of times (23). This included restoration of wetlands and streams, as well as soft shoreline restoration strategies. Addressing this on an ecosystem level would focus on the need for species and habitat preservation, with additional concern for water temperature impacting aquatic species. Highlighted here is the need for an increased valuation of preserving and restoring natural areas in decision-making processes. This is closely related to the policy and planning needs for decision support in development projects (14), as understanding the impacts from development is an important part of decision-making and planning processes.

Table 2. The number of times interviewees talked about different climate issues, subdivided into the three main discussion areas. RPP = Research, Policy and Planning; ET = Education and Training; CCL = Coordination, Collaboration and Leadership

Discussion Area	Issue Category	# Times
RPP	Water Management (Quantity): <i>Stormwater, flooding, CSO overflow, heavy rain and snow, flooding impacts on septic systems and basements, aging infrastructure.</i>	33
RPP	Water Management: (Quality): <i>Water quality, drinking water quality, beach quality, wastewater treatment, wastewater treatment plants, sewage.</i>	26
RPP	Ecosystem Based Management: <i>Habitat, natural area, and soft shore preservation and restoration (streams, wetlands, aquatic habitat and organisms), valuing natural areas as priority for decision-making, wildlife protection and species preservation.</i>	23
RPP	Policy and Planning: <i>Decision support for development projects, understanding and anticipating development impacts, associated economic concerns.</i>	14
RPP	Coastal Planning: <i>Lakes level changes, impacts on coastal infrastructure and property, specific wet weather impacts in coastal zone, erosion.</i>	13
RPP	Ship Navigation: <i>water temperature, ice cover.</i>	6
ET	Education: <i>Comprehensive science education, ecological awareness in youth, continuing social-ecological cycle of knowledge gathering and building, training scientists.</i>	23
ET	Public Health: <i>Extreme temperatures, poor air quality, heat related stress, planning for heat emergencies, harmful algal blooms.</i>	11
ET	Training: <i>Access to tools, awareness of needs, building out competencies, education and training for decision-makers.</i>	10
ET	Economic: <i>Impacts on economy, decision support for budgeting.</i>	5
CCL	Coordination: <i>Need consistency in government and other agencies, improved communication and coordination across federal, state, and local levels.</i>	27
CCL	Leadership: <i>Need for capacity-building.</i>	21
CCL	Coordination: <i>Information accessibility and distribution at community and watershed scales, public involvement.</i>	19
CCL	Barriers: <i>Lack of political will, distrust of officials.</i>	8

With specific attention to coastal planning, interviewees raised concerns about fluctuating and falling lake levels, as well as specific wet weather impacts in the coastal zone, and the consequent impacts on coastal infrastructure and property. Maritime navigation and port industries are also affected by changes in water level (6). One city planner talked about the increased cost of dredging channels for ships to pass through:

“They would have to deepen their channel that leads to the dock. They were not able to fully load the ships because of the draft problem, and so that of course costs money because you’re not able to fully load a ship, simply because it can’t get in and out of the dock area. And the cost of dredging those channels gets to be very expensive, because in many cases those channels where those boats go through, the bottom is rock.”

- City Planner

Bank erosion was a specific concern, and could be considered in the context of natural area preservation and ecosystem based management. The total number of topics that were mentioned in the coastal planning category was thirteen.

Education and Training

At the top of this list is the need for comprehensive education in all forms (23). A strong science and ecology curriculum from kindergarten through high school would set the foundation for development of long term solutions, which interviewees spoke strongly in support for when discussing education. Continuing to train aspiring scientists in college and graduate school programs would also further sustain ongoing efforts to

understand and adapt to the impacts of climate change. Public education was also perceived as needed; topics that were mentioned included watershed awareness, pollution reduction, and creating rain gardens.

Public health concerns included experiencing new extreme temperatures, urban heat islands, heat related stress and impacts on vulnerable populations, poor air quality, and planning around heat emergencies (6). One interviewee, an environmental health agency Director, spoke about how it will be necessary for people to adjust to “Florida weather” here in the Great Lakes region, and that while people who are already accustomed to such weather know what to do, people unaccustomed to extreme heat – and especially in this region- are not likely to anticipate extreme heat or to plan properly. This lack of preparation will draw on emergency management resources, an area where comprehensive training would be a tremendous benefit for increasing public service capacity, with an equal emphasis on preparedness and prevention.

Other health concerns include algae growth and harmful algal blooms (5), also associated with an increase in temperature. This has both health and economic implications for local and tourist communities. People visiting beaches for swimming need to be informed of water quality and associated health hazards. Harmful algal blooms are a significant issue for the western basin of Lake Erie.

One natural resource manager spoke about the economic consequences of algae blooms, as tourists become less likely to visit beaches and use the water recreationally. This has a negative economic impact on local businesses that rely on the tourist industry for a significant part of their business income.

Further concerns included decision support and staff training to develop budgets for programs, as well as anticipating what the staffing needs will be for different projects (5). Specific training needs included having access to and proficiency in using tools, awareness of what the local needs are, and comprehensive training in basic competencies (such as heat emergencies)(1). One environmental health professional wondered about what those basic competencies might be, once awareness is established. Preparedness and prevention of public health issues and the related need for public outreach were talked about as an integrated training need in this interview, and that training programs could include effective communication strategies. In an interview with a neighborhood planner, having resources and materials to help guide decision making and as a reference tool when implementing training was also mentioned (1). Finally, there was discussion of the need for education of decision-makers, which emerged as an issue numerous times and is included in the following section on coordination and leadership.

Coordination, Collaboration and Leadership

The need for better communication and coordination between agencies was mentioned in various instances, with emphasis at the federal, state, and local scales (27). This perceived fragmentation in government was considered to be one of the most significant barriers to development of policies or planning for climate change. Similarly, the need for leadership at each of these scales was discussed almost as frequently (21), with emphasis on the need for high level advocacy for climate planning, leadership and education for decision-makers.

Specific government levels identified as benefiting from increased coordination included better coordination with state governments, as well as at the county level. In one instance, a county water management employee discussed how having an official Department of Environment holds much more authority and persuasion when implementing regulation and policy. The interviewee made this clear by comparing how it sounds when a professional can say they are from the Department of Environment, as opposed to being from a division of another department.

Several interviewees noted that strengthening physical networks of people, in professional networks and in communities, is needed to increase coordination and improve communication. Within government, one city planner thought it would be useful to have an intranet for city employees. In the environmental health field at the county level, an agency director talked about fragmentation across agencies and departments, and the need to work together:

“We realize there is so much fragmentation, there is a lack of communication and coordination. People have their missions and they are just following it down without realizing they can get more of their missions accomplished by helping other people accomplish their missions, if we are all working together, whether it’s federal, state or local level. That’s a barrier, a big barrier. We have to get out of our silos.”

- County agency director

Another participant framed the issue from an ecosystem perspective, signifying the importance that decision-makers have the necessary information and education to empower effective action, because when funds are appropriated for large scale projects, such as with the Great Lakes Restoration Initiative, it encourages agencies to work together and overcome institutional boundaries. The need for increased coordination and improved communication spans the local to international scale, as the Great Lakes basin spans both the U.S. and Canada. Concerning leadership:

“The individual has [to have] the vision to see that ‘if I participate here or allocate resources here, it will actually meet our mission because we’ll accomplish something else that’s down the road’. So we have to have the vision, like chess players, to see ten plays beyond where we are.”

- Agency director for basin-scale research collaboration

Current climate change information distributed and made accessible at the community scale was identified as a need in twelve instances. Additionally, involving community in decision-making, understanding public perception, having local leadership, and identifying issues based on data were seen as needed for effective climate change planning (5). Each of these needs also fit under a larger umbrella of social and cultural change that is perceived as needed for effective action to occur.

One water manager spoke of the importance of climate impacts on food resources for tribes, and the need for watershed models to aid in planning efforts. As water levels fluctuate or decline, this influences crop yields for wild rice, a significant food staple.

The tribe had recently undertaken a watershed study to understand the hydrology of the area, and was subsequently reassured that they would be able to monitor wild rice lakes and anticipate climate impacts on the area.

Being able to address issues on a watershed scale was a shared concern. Addressing issues on a watershed scale – and even a subwatershed scale - is part of an ecosystem perspective and developing adaptive management capacity. While having local information was seen as necessary for decision-making, barriers were perceived for developing watershed solutions, with political agendas and the political will for action seen as specific local issues (6), as well as any scientific uncertainty, real or perceived, causing distrust of officials (2). A watershed perspective was mentioned quite emphatically on two occasions as being necessary for long term solutions for adapting to changes in climate, emphasizing the importance of addressing climate change:

“[climate change] is a priority. Things are going to change and we’ve got to get beyond what the cause is and think about some solutions at the local level.” - Watershed planner

Discussion

The overarching need for improved coordination is consistent with findings from Desotelle Consulting et al. (Desotelle Consulting et al. 2006a, 2006b). Improving coordination and communication between levels of government and with other agencies, especially across jurisdictional boundaries, was emphasized in the interview phase of the needs assessment. Leadership training and demonstrating leadership at all levels was seen as an important priority. Fragmentation in government was considered one of the most significant barriers to develop policies or plan for climate change. Some participants believed that strengthening professional networks and intranet communication systems would facilitate the exchange of knowledge and information, consistent with a theory of efficacy of a regime network to promote environmental sustainability (Ward 2006). Other coordination issues identified were information accessibility and distribution at the local scale, consistent with findings that practitioners need local information (Desotelle Consulting et al. 2006a, 2006b; Mycoo and Gobin 2013). Additionally, engaging community in all stages of planning and decision-making can identify strong perspectives early enough in the process to find solutions all stakeholders can agree upon, thus making long-term solutions more likely to succeed when implemented (Fauver 2008; USEPA 2013). Implementing ecosystem based management strategies can create educational opportunities for increasing watershed awareness and strengthen community involvement, as demonstrated by the Huron River Watershed Council in Ann Arbor, Michigan (Huron River Watershed Council 2013). Developing communication systems and networks that empower professionals to effectively and promptly exchange knowledge and information will facilitate coordinated action (USEPA 2008b; Fauver

2008, Joseph et al. 2009; Quigley et al. 2009; USEPA 2013). Education for decision-makers and ensuring that policy recommendations and climate adaptation training materials are accessible and up to date for decision-making, especially when budgeting for programs, will help ensure funding for critical and relevant projects and strengthen adaptive capacity. Education of decision makers is critical for effective leadership and would serve to improve coordination at all scales, including federal, state and local, by demonstrating agency leadership and strengthening partnerships (USEPA 2008b; Fauver 2008; NRC 2009). Concerning funding for ecological restoration projects, interview participants perceived lack of funding as a barrier, consistent with findings from the NOAA needs assessment workshop (Joseph et al. 2009; Quigley et al. 2009), although interview participants felt this barrier was somewhat reduced by having near and long term planning goals and projects already identified on paper, which can be undertaken as soon as funding becomes available.

Water management issues concerning both quantity and quality ranked high on the issue list, along with the need for ecosystem based management strategies for habitat and natural area preservation, and concerns about changes from aquatic invasive species in food webs all reiterate the findings from the NOAA needs assessment workshop (Joseph et al. 2009; Quigley et al. 2009). Interviewee concerns about beach quality and health hazards, such as high bacteria levels, is supported in the literature, as these hazards compromise the recreational use of beaches and can deter tourists (Lise and Tol 2002; Sturtevant 2004; Fauver 2008; Patz et al. 2008; Joseph et al. 2009; Quigley et al. 2009). Coastal planning for lake level changes and resilient coastal infrastructure were discussed in nearly all of the interviews, emphasizing the need for decision support resources that

identify and characterize anticipated coastal climate impacts, also consistent with discussion on contextual relevance of uncertainty in decision-making (Moser 2012) and the need for interactive learning environments to support coastal managers (Tribbia and Moser 2008). Water treatment systems and built infrastructure operating capacities should be evaluated and modified according to current precipitation trend data to meet local information needs and reduce uncertainty in decision-making (Fauver 2008). Coastal planning has specific infrastructure considerations; soft shore restoration and erosion control strategies can be developed and shared among professional and community networks, improving coordination and knowledge sharing efforts (Fauver 2008). Planning processes could integrate an ecosystem perspective that makes natural area preservation and restoration a priority to address stormwater runoff, flooding, and development impacts, and increase resilience to these impacts (Safford et al. 2005; Fauver 2008). Education and training efforts should communicate the differences between climate change mitigation and adaptation, and focus on strategies that lead to action in planning and implementation (Fauver 2008). Some actions will integrate both mitigating and adapting capacities, and are recommended as priority measures for action (NRC 2009). Training and resource materials for basic competencies could range from general climate change awareness to sector specific issues, such as public health and extreme heat events, depending on training and information needs (NRC 2009; Old Woman Creek National Estuarine Research Reserve 2011; Conlon et al. 2014).

Finally, it is important to note that some impacts may differently affect subsets of the population, as some groups are more vulnerable to certain climate impacts (Whyte 2013). A specific example mentioned in one of the interviews is the impact of water level

fluctuation on the yield of wild rice, and the potential for climate impacts on hydrology to decrease the availability of a major food source for some Tribes and First Nations in the Great Lakes region.

Concluding Remarks

The issues that were brought forth in the interview portion of the needs assessment covered a wide range of topics, as well as illuminating the variation in awareness of climate change and the anticipated impacts. As the interviews were a subset of the needs assessment, it is interesting to see how having in-depth qualitative data from the interviews brought insight to develop a broader survey instrument, and enhanced the calibration of the survey instrument for deployment. While the Great Lakes cover a large span of territory, it still functions as one large ecosystem. The people within that ecosystem may all be affected with very similar changes in the system across the lakes, yet still experience climate impacts specific to the lake region that they are in. There were certainly some common concerns across the basin, such as having uncertainty around types and severity of different impacts, and each interviewee was able to provide unique insight and perspective, bringing to light the multi-faceted nature of climate adaptation. Having conversations with people from each of the five lake basins was a valuable and diverse component to the overall assessment, and each of the participants appreciated the opportunity to speak about their concerns and perspective. For further details, the final interview report submitted to the Old Woman Creek Research Reserve client organization and the final NOAA needs assessment synthesis report that includes information from all tiers of data collection are included in the appendices.

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Appendix A: Preliminary Data Collection

Great Lakes Conference Attendee Paper-based Survey

“The nine attendees responding to the survey displayed a high level of awareness and concern regarding climate change, regional impacts, and adaptation planning. Nearly all survey respondents have already been engaged in adaptation planning or are planning to become involved.

Water quality, recreation and tourism, and carbon emissions reduction were most frequently identified as top priorities for adaptation planning. No survey respondents identified shipping or human health as priorities for adaptation and only three identified disaster preparedness. Ecosystem-based management was the most frequently indicated adaptation strategy (4); followed by strategic plans focused on climate change, climate related policies, and dedicated funding (3); and zoning ordinances (1).

All respondents identified lack of funding as a barrier to adaptation planning. Limited staff time and technical capabilities were seen as barriers by four respondents (4); lack of knowledge and institutional inertia by three (3); and lack of public support by one (1). Reduced economic losses (6) and meeting political and public demand (5) were the most frequently identified benefits to developing adaptation plans.

Five (5) respondents indicated that their communities or organizations have gathered information about potential impacts and adaptation strategies for infrastructure; three (3) for ecology, public safety, and transportation; two (2) for commerce, housing, and energy; and one (1) for public health.

Education about impacts, financial assistance, and strategies for communicating with the public were identified as most useful for supporting adaptation planning by four (4) respondents. Technical expertise and tools were identified as most useful by three (3) and guidance with policy by one (1).

Forecast modeling was the most frequently identified (6) as a tool needed for adaptation planning. Funding to purchase software (6) was seen as a major barrier to accessing tools. Six (6) respondents indicated that highly sophisticated tools would be useful.

Coordination and/or collaboration between agencies was the most frequently identified need to support planning and decision-making (6), followed by access to local and/or real-time data, technical assistance, facilitation support, and communication between agencies and training on adaptation strategies (4).”

This information was provided by Heather Elmer on behalf of the client organization, the Old Woman Creek National Estuarine Research Reserve

Appendix B: Interview Question Set

- 1) Could you briefly describe your work?
 - Scope
 - Nature of work
 - Decision-making authority
- 2) How does weather impact what you do?
 - Daily, seasonally, annually
 - Scale of area
- 3) Would changes in weather or climate effect any built or natural infrastructure¹ that you manage? If so, how?
- 4) What are the planning timeframes used by your agency?
- 5) Do you see a need to expand planning windows in your management or planning strategies?
 - 5a) What would be some of the benefits of this for your work?
 - 5b) What might be some of the barriers to expanding these windows?
- 6) What is your perspective on and understanding of a changing climate in the Great Lakes region?
 - 6a) How do you think a changing climate might effect:
 - Human health?
 - Human safety?
 - Environmental quality?
 - Economy?
 - Property?
 - 6b) Do you think that these impacts would be positive or negative?
 - 6c) Of the negative impacts that have been mentioned, which might inflict the greatest losses (economic, social, or environmental)?
- 7) Are there any management or planning actions that directly or indirectly address climate change in your community? If so, what are they? If not, can you foresee an action that would help to avoid future losses, if implemented?

¹ Infrastructure defined as: the basic facilities, services, networks, and systems needed for the functioning of a community that if lost or damaged could cause significant disruption (physically, functionally, and economically).

8) Is climate change adaptation planning a priority for your community or organization?

8a) (If no) what factors influence or prohibit climate change planning as a priority?

8b) (If yes) If you've been engaged in climate change planning, where is your community in that process?

⇒ Priority, but no action: What do you need to facilitate your planning?

⇒ Planning in process: What kind of barriers have you encountered?

- What resources are currently helpful?
- What resources or training do you feel are missing?

⇒ Plan complete: What factors made it successful?

- What barriers did you encounter?
 - What did you need that was missing?
 - What did you need in technical capacity? Training?
-

Appendix C: Deliverable 1: Interview Results

Planning for Climate Change in the Great Lakes Needs Assessment

Interview Results

Report prepared for the Old Woman Creek
National Estuarine Research Reserve

May 2012



President Barack Obama has committed to making Great Lakes restoration a national priority. The Great Lakes provide drinking water to over 30 million Americans and support a multi-billion dollar economy. Since February 2009, President Obama has proposed significant funding as part of his Great Lakes Restoration Initiative, the most significant investment in the Great Lakes in two decades. For more information on President's initiative and the action plan, go to www.greatlakesrestoration.us



Old Woman Creek is one of 28 NOAA National Estuarine Research Reserves that improve coastal stewardship through research, education, and demonstration. Old Woman Creek translates science conducted on the reserve and elsewhere to community leaders and decision-makers, students, and residents to increase understanding and stewardship of Lake Erie coastal wetlands and watersheds. To learn more about Old Woman Creek visit www.oldwomancreek.org or www.estuaries.gov

Old Woman Creek National Estuarine Research Reserve
Great Lakes Restoration Initiative FY2010
Planning for Climate Change in the Great Lakes
Needs Assessment
Interview Results

Dawn Nelson
P.O. Box 8083
Ann Arbor, MI 48107
anadawn@umich.edu
734.277.7121

Practicum Report in partial fulfillment of the requirements for the
Master of Science degree at the
School of Natural Resources and Environment
University of Michigan – Ann Arbor

1. Table of Contents

1. Table of Contents 3

2. Project Overview 4

3. Objectives 5

4. Target Audience 5

5. Method..... 7

 5.1 Needs Assessment as Two-Phase Project..... 7

 5.2 Data Collection 7

 5.3 Sample Description 8

 5.4 Data Analysis 9

6. Results: Top Ten Issue Categories 10

7. Discussion of Needs: Research, Planning, and Policy..... 12

 7.1 Priority Issue Categories 12

 7.2 Recommendations 13

8. Discussion of Needs: Education and Training..... 15

 8.1 Priority Issue Categories 15

 8.2 Recommendations 17

9. Discussion: Coordination and Leadership 18

 9.1 Highlighted Needs 18

 9.2 Recommendations 20

10. Discussion: Watershed Scale Collaboration and Local Governance 21

 10.1 Highlighted Needs 21

 10.2 Recommendations 22

11. Planning Timeframes 23

 11.1 Recommendations 23

12. Summary of Recommendations 24

13. References 26

14. Interview Questions..... 27

2. **Project Overview**

The goal of this needs assessment was to collect sufficient information about the knowledge, skills, interest, attitudes, and ability of Great Lakes coastal community planners, stormwater managers, and natural resource managers to design effective training that increases the ability of these groups to confront and adapt to the impacts of climate change. This study was conducted in two phases, with funding for the first phase from the NOAA Sea Grant Climate Engagement Project, and funding for the second phase via President Obama's Great Lakes Restoration Initiative¹. The first phase synthesized existing information and literature, the process of which served to inform the development of the NOAA Sea Grant Climate Ready Great Lakes training modules. This synthesis was then finalized into a technical report and made accessible on the NOAA Great Lakes Environmental Research Laboratory website (Nelson et al, 2011).

The second phase consisted of data collection to assess training and information needs. Research from Tribbia and Moser (2008) demonstrates the need for information and learning opportunities for coastal managers to understand and anticipate climate change impacts (Tribbia and Moser, 2008). As climate impacts are specific to a region, the fifteen interviews conducted in this study are specific to the Great Lakes region. This report includes the interview sample results from the three part needs assessment, and is a supporting document to the full report that includes results from the survey and focus groups. The data collection phase was coordinated through the Old Woman Creek National Estuarine Research Reserve (NERR) in Huron, Ohio. Phase two results and recommendations are a companion document to the needs synthesis report². The Great Lakes Sea Grant Network and Old Woman Creek National Estuarine Research Reserve is utilizing the results of both phases of this needs assessment to design climate change adaptation training for Great Lakes coastal community decision-makers and

¹ Funding for this project was received via President Obama's Great Lakes Restoration Initiative. For more information on the Initiative and Action Plan go to www.greatlakesrestoration.us

² Nelson, D., H. Elmer, R. Held, D. Forsyth, and S. Casey. 2011. *Laurentian Great Lakes Basin Climate Change Adaptation*. NOAA Technical Memorandum GLERL-153. Available at www.glerl.noaa.gov/pubs/techrept.html

professionals. Study results and recommendations can also guide future needs assessments and investments in Great Lakes climate change adaptation training.

3. Objectives

- Identify and describe the following for Great Lakes coastal community planners, stormwater managers, and natural resource managers with regard to climate change:
 - Current state of awareness, knowledge, and skill
 - Perceptions and attitudes regarding the issue of climate change and whether/how it is connected to community planning, stormwater, and natural resource management
 - Understanding of potential economic impacts
 - Orientation toward adaptive, mitigative, and combined responses
 - Barriers to and benefits of adaptation planning
 - Attitudes toward planning and decision-making in the face of scientific uncertainty
 - Need for training and tools
 - Learning styles and preferred training formats

4. Target Audience

A general description of the initial target audience includes professional planners, stormwater managers, and natural resource managers working in Great Lakes coastal counties or watersheds. Additionally, emergency managers were included as an emerging and important role within an interdisciplinary response to climate change adaptation.

Specific roles:

- Planner
 - Professional Planner - land use, transportation, ports, energy, water infrastructure
 - Sustainability Director
 - Zoning Director/Administrator
 - Director of Housing and Business Development
 - Energy Procurement Manager

Planning for Climate Change in the Great Lakes Needs Assessment: Interview Results

- Stormwater manager
 - Public Works Director
 - Engineer
 - Public Service Director
 - Permitting Authorities
 - Municipal Separate Storm Sewer System (MS4) Program Coordinator
 - Stormwater Plan Reviewer

- Natural resource manager
 - Parks and recreation director
 - City Forester
 - Park manager

- Policy-maker
 - City Councilmember
 - Township Trustee
 - Mayor
 - County Commissioner
 - State Representative
 - Representatives and Staff on State Legislature Natural Resource and Environment
 - committee
 - Staff on State Departments of Natural Resources and Departments of Environmental Quality and Protection

- Emergency Manager
 - County Agency Director
 - Municipal Manager
 - Water Manager
 - Emergency Management Director
 - Public Health and Safety Director

5. **Method**

5.1 Needs Assessment as Two-Phase Project

This needs assessment was conducted in two phases, with the initial synthesis of existing literature serving to inform the second phase of data collection, as well as the development of the Great Lakes Sea Grant climate adaptation training modules *Climate Ready Great Lakes* (Casey et al, 2011). The first phase synthesis of existing literature is available in the NOAA technical memorandum *Laurentian Great Lakes Basin Climate Change Adaptation* (Nelson et al, 2011). The needs from this report were further condensed into ten overarching needs, and then revised again once the data collection and analysis were completed to reflect the new information found in the survey and interview data.

5.2 Data Collection

A three tier approach for data collection was used to identify information and training needs. Beginning with in-person and telephone interviews, this information has informed the second and third tier of data collection. The second tier included the focus groups, and the third tier was an online survey during the months of January and February.

Data collection for interviews and focus groups took place from July through September 2010. Throughout the month of July, a subject pool was constructed from existing datasets to recruit participants for interviews and focus groups. This participant database included many of the working professionals in the coastal Ohio counties. The subject pool is generally constrained to one coastal county inland, although in some cases two, but no more than three, counties inland. This enables a watershed perspective to identify issues, which is one of the recurring themes in the data. It is noted that NOAA identifies 158 Great Lakes coastal counties, which includes nearly all of the state of Michigan.

Invitations to participate were sent by email in July, with immediate positive response for both interview and focus group participation. Interviews were estimated to take 30 to 45 minutes, and this proved to be a sufficient amount of time to answer a set of eleven questions. Once this method for eliciting interview participation yielded little or no response, continuing recommendations were requested of Sea Grant Extension Agents and other professionals

working closely with the needs assessment team, yielding a larger subject pool. These interviews are considered ‘key informant’ interviews.

In-person and telephone interviews were conducted across the Great Lakes States, as well as two focus groups in Ohio. Fifteen interviews were conducted in August and September. Focus group participation consisted of one group of four people and one group of five people.

5.3 Sample Description

An interdisciplinary approach was taken in order to gauge what the issues might be across separate yet similar sectors. This is represented in the interview subject pool:

- Interviews: 15
 - 4 Planners
 - 2 Watershed managers
 - 4 Water managers
 - 3 Natural resource managers
 - 2 Program directors (1 public health, 1 environmental education)

- ❖ Regions represented:
 - New York
 - Ohio
 - Michigan
 - Minnesota
 - Wisconsin
 - Illinois
 - Tribal

- ❖ Lake Basins:
 - Erie
 - Ontario
 - Huron
 - Superior
 - Michigan

- Focus groups: Two sessions were held in the Lake Erie coastal zone of Ohio.

Initial take home messages:

- (Phase I): Two cross cutting themes were identified both in existing literature and through Cities Initiative feedback: Top priority needs that cut across issues from infrastructure to ecosystem based management are
 - Communication, Coordination, and Collaboration
 - Data Integration and Information Distribution

- Climate change planning may be taking place across departments in a municipality or county but in a fragmented form, e.g. stormwater planning and/or emergency response, but were not formally associated as part of a climate change action planning process.

5.4 Data Analysis

Audio-recorded data from interviews and focus groups were transcribed, with partial support from administrative staff at Old Woman Creek NERR. Each interview transcription was then summarized to facilitate synthesis and reporting of the data. Content categories were formed through a coding process that identified the topics mentioned by each participant. Topics were then tallied and categorized in matrix form. Topics falling under the main headings of the issue categories were counted once per interview. For example, a participant may have talked about a topic extensively, but it was counted only once. This could be considered a limitation of this study, as there isn't a weighted differentiation as to whether an issue was spoken of briefly or extensively. However, this is balanced by including some of the raw qualitative data, as each section includes direct quotes from participants.

The major issue categories are grouped as discussion areas for research, policy, and planning needs; education and training needs, coordination and leadership, and watershed scale decision-making. A list of the topics included in each issue category are elaborated in the following section and grouped by these discussion areas.

6. Results: Top Ten Issue Categories

In sum, the top ten issue categories mentioned across interviews were as follows, with the number on the right representing the number of times a topic emerged across all interviews (topics falling under these issue categories were counted once per interview).

➤ Water Management: Quantity	33
➤ Coordination, Barrier: Fragmentation in government and other agencies	27
➤ Water Management: Quality	26
➤ Ecosystem Based Management: Habitat and natural area preservation and	23
➤ Education: Comprehensive science education	23
➤ Leadership, Barrier: Absence of leadership	21
➤ Policy and Planning: Decision support for development projects	14
➤ Coastal Planning: Lake level change and coastal infrastructure	13
➤ Coordination: Information accessibility and distribution at the community scale	12
➤ Navigation: water temperature increase, less ice cover	6

The topics in each of these categories are grouped in four discussion areas as follows:

Research, policy and planning

- Water Management, Quantity: *Stormwater, flooding, CSO overflow, heavy rain, flooding impacts on septic systems, basement flooding, heavy snow.*
- Water Management, Quality: *Water quality, bathing beach quality, drinking water quality, wastewater treatment, wastewater treatment plants, sewage.*
- Ecosystem Based Management: *Habitat and natural area preservation and restoration (streams, wetlands, aquatic habitat and organisms), softshore preservation & restoration, valuing natural areas as priority for decision-making, wildlife protection and species preservation, need restoration strategies for soft shores.*
- Policy and Planning: *Decision support for development projects, understanding and anticipating development impacts.*
- Coastal Planning: *Lakes level changes, impacts on coastal infrastructure and property, specific wet weather impacts in coastal zone, erosion.*

Education and Training

- Education: *Comprehensive science education; increase ecological awareness in youth; continuing social-ecological cycle of knowledge gathering and building, training scientists.*
- Health and Safety, Emergency Management: *Extreme temperatures, heat related stress, poor air quality, planning around heat emergencies.*
- Ecosystem Based Management, Health and Safety: *Harmful algal blooms.*
- Economic: *Education and decision support for program budgeting.*
- Training: *Access to tools, awareness of needs, building out competencies.*

Coordination and Leadership

- Coordination as barrier: *Need consistency in government, improved communication and coordination across Federal, State, and local levels.*
- Leadership as barrier: *Need leadership at Federal, State, local, and tribal levels.*
- Coordination and communication: *Need physical networks of people, from local to international scale.*

Watershed Scale Collaboration and Local Governance

- Coordination: *Information accessibility and distribution: community scale.*
- Policy as barrier: *Remove political barriers to watershed solutions.*
- Social: *Need cultural change, public involvement and leadership.*
- Communication as barrier: *Uncertainty causing distrust of officials.*
- Ecosystem Based Management: *Addressing issues on a watershed scale.*

7. **Discussion of Needs: Research, Planning, and Policy**

7.1 Priority Issue Categories

- Water Management, Quantity: *Stormwater, flooding, CSO overflow, heavy rain, flooding impacts on septic systems, basement flooding, heavy snow.*
- Water Management, Quality: *Water quality, bathing beach quality, drinking water quality, wastewater treatment, wastewater treatment plants, sewage.*
- Ecosystem Based Management: *Habitat and natural area preservation and restoration (streams, wetlands, aquatic habitat and organisms), softshore preservation & restoration, valuing natural areas as priority for decision-making, wildlife protection and species preservation, need restoration strategies for soft shores.*
- Policy and Planning: *Decision support for development projects, understanding and anticipating development impacts.*
- Coastal Planning: *Lakes level changes, impacts on coastal infrastructure and property, specific wet weather impacts in coastal zone, erosion.*

Water management in terms of quantity rose to the top of the list of concerns, with topics under this heading emerging thirty-three (33) separate times across interviews. Water from storms, heavy rain, and snow can cause flooding, impacting infrastructure, including septic systems and basements. Similarly, water management as an issue of quality (26) included both drinking water and bathing beach quality. Wastewater treatment and the need for treatment plants to be able to perform effectively given increased intensity of precipitation events was also a concern. One natural resource manager also highlighted the need for more research on the effects of atmospheric acids on the lakes, and another spoke of the need for research on the impact of Asian carp on the aquatic food web.

Natural area preservation as a function of ecosystem based management was also mentioned a number of different ways (23). This included restoration of wetlands and streams, as well as soft shoreline restoration strategies. Addressing this on an ecosystem level would also address the need for species and habitat preservation, with additional concern for water temperature impacting aquatic species. Highlighted here is the need for an increased valuation of preserving and restoring natural areas in decision-making processes. This is closely related to the

policy and planning needs for decision support in development projects (14), as understanding the impacts from development is an important part of decision-making and planning processes.

With specific attention to coastal planning, interviewees raised concerns about fluctuating and falling lake levels, as well as specific wet weather impacts in the coastal zone, and the consequent impacts on coastal infrastructure and property. Industries are also affected by changes in water level; one city planner talked about the increased cost of dredging channels for ships to pass through:

“They would have to deepen their channel that leads to the dock. They were not able to fully load the ships because of the draft problem, and so that of course costs money because you’re not able to fully load a ship, simply because it can’t get in and out of the dock area. And the cost of dredging those channels gets to be very expensive, because in many cases those channels where those boats go through, the bottom is rock.”

-City Planner

Bank erosion was a specific concern, and could be considered in the context of natural area preservation and ecosystem based management. The total number of topics that were mentioned in the coastal planning category was thirteen (13).

7.2 Recommendations

- Planning processes could integrate an ecosystem perspective that makes natural area preservation and restoration a priority in decision-making processes. This would also include anticipating stormwater runoff, the potential for flooding, and development impacts over the long term.
- Water treatment systems and infrastructure should be evaluated as to whether operating capacity is likely to become overwhelmed, due to changing precipitation patterns associated with climate change, and plans to upgrade and/or replace systems should be

developed and implemented. Precipitation trend data should be accessed in order to gauge what is reasonable to anticipate in terms of new operating capacities.

- Coastal planning has specific infrastructure considerations, and is closely related to the need for natural area preservation and restoration. Soft shore restoration and erosion control strategies can be developed and shared among professional networks, as well as through public information channels at the local scale. Built infrastructure can be evaluated, upgraded, and/or replaced to address intermodal operational capacity in the context of lake level changes, both short and long-term.

8. **Discussion of Needs: Education and Training**

8.1 Priority Issue Categories

- Education: *Comprehensive science education; increase ecological awareness in youth; continuing social-ecological cycle of knowledge gathering and building, training scientists.*
- Health and Safety, Emergency Management: *Extreme temperatures, heat related stress, poor air quality, planning around heat emergencies.*
- Ecosystem Based Management, Health and Safety: *Harmful algal blooms.*
- Economic: *Education and decision support for program budgeting.*
- Training: *Access to tools, awareness of needs, building out competencies.*

At the top of this list is the need for comprehensive education in all forms (23). A strong science and ecology curriculum from kindergarten through high school would set the foundation for development of long term solutions, which interviewees spoke strongly in support for when discussing education. Continuing to train aspiring scientists in college and graduate school programs would also further sustain ongoing efforts to understand and adapt to the impacts of climate change. Public education was also perceived as needed; topics that were mentioned included watershed awareness, pollution reduction, and creating rain gardens.

Public health concerns included experiencing new extreme temperatures, urban heat islands, heat related stress and impacts on vulnerable populations, poor air quality, and planning around heat emergencies (6). One interviewee, an environmental health agency Director, spoke about how it will be necessary for people to adjust to “Florida weather” here in the Great Lakes region, and that while people who are already accustomed to such weather know what to do, people unaccustomed to extreme heat – and especially in this region- are not likely to anticipate extreme heat or to plan properly. This lack of preparation will draw on emergency management resources, an area where comprehensive training would be a tremendous benefit for increasing public service capacity, with an equal emphasis on preparedness and prevention.

“One of the issues is getting our emergency management teams talking about it—through drills, and through regular series of meetings, and indicators that we need to have to talk about these issues and where we’re at.”

-County agency director

Other health concerns include algae growth and harmful algal blooms (5), also associated with an increase in temperature. This has both health and economic implications for local and tourist communities. People visiting beaches for swimming need to be informed of water quality and associated health hazards. Harmful algal blooms are a significant issue for the western basin of Lake Erie.

“The same situations that encourage the algae blooms also encourage situations which create the growth of pathogens that are harmful to people and animals and wildlife in general. We can fix these things, however there are things going on, on a short-term basis. Right at the moment we’re not necessarily going in the right direction or fast enough, or maybe we’re going in the right direction but certainly not fast enough.”

-County water pollution inspector

One natural resource manager spoke about the economic consequences of algae blooms, as tourists become less likely to visit beaches and use the water recreationally. This has a negative economic impact on local businesses that rely on the tourist industry for a significant part of their business income.

Further economic concerns included decision support and staff training to develop budgets for programs, as well as anticipating what the staffing needs will be for different projects (5). This is also a key area to address the need for education for decision-makers, which emerged as an issue in (8) instances and is included in the following section on coordination and leadership.

Specific training needs included having access to and proficiency in using tools, awareness of what the local needs are, and comprehensive training in basic competencies (such as heat emergencies). One environmental health professional asked,

“Once we build out the awareness of what we need, then what competencies are we going to need?”

Preparedness and prevention of public health issues and the related need for public outreach were talked about as an integrated training need. New programs in this regard could include training in effective communication strategies.

“Quite a bit of education we will have to do with residents about changes that are happening and will continue to happen. In terms of communicating to people and thinking about what our new baseline is going to be for the watershed, is helping [people] to understand that we’re going to see things changing like the type of tree composition we have, what is going on with our fish communities, water temperatures.” –Watershed planner

Having resources and materials to help guide decision making and as a reference tool when implementing training was also mentioned:

“A guide book of sorts would probably be most beneficial, to go along with that, a basic training should inform us of the guidebook. When you get new material in front of you, you have to have some training so you’re familiar with it so you can address these issues in meetings and be knowledgeable about the topic.” –City and neighborhood planner

8.2 Recommendations

- Education for decision-makers when budgeting for programs to ensure proper resources and staffing are allocated.
- Training in basic competencies specific to issue.
- Training and/or resource materials for communication strategies, general to climate change awareness as well as issue specific.
- Ensure guidance materials are accessible and up to date for decision-making.

9. **Discussion: Coordination and Leadership**

9.1 Highlighted Needs

- Coordination as barrier: *Need consistency in government, improved communication and coordination across Federal, State, and local levels.*
- Leadership as barrier: *Need leadership at Federal, State, local, and tribal levels.*
- Coordination and communication: *Need physical networks of people, from local to international scale.*

The need for better communication and coordination between agencies was mentioned in various instances, with emphasis at the Federal, State, and local scales (27). This perceived fragmentation in government was considered to be one of the most significant barriers to development of policies or planning for climate change. Similarly, the need for leadership at each of these scales was discussed almost as frequently (21), with emphasis on the need for high level advocacy for climate planning, leadership and education for decision-makers. (The need to educate decision-makers is also included in the discussion on education and training.)

Specific government levels identified as benefiting from increased coordination included better coordination with state governments, as well as at the county level. In one instance, a county level water management employee discussed how having an official Department of Environment holds much more authority and persuasion when implementing regulation and policy. The interviewee made this clear by comparing how it sounds when a professional can say they are from the Department of Environment, as opposed to being from a division of another department.

Some interviewees noted that strengthening physical networks of people, both professionally and as communities, is needed to increase coordination and improve communication. Within government, one planner thought it would be useful to have an intranet for city employees:

“We don’t really interact with these other departments unless called into from a department head. So maybe some sort of inter or intranet where we’re able to access what’s going on, maybe some news and updates on the city would be something beneficial to everyone that works for the city.”

Additionally, he pointed out that it is important to be cognizant of email frequency:

“You really have to weigh what is important and when to send out email messages, otherwise I think people lose interest in it quick or don’t even take it into account anymore.”

-City and neighborhood planner

In the environmental health field at the county level, an agency director talked about fragmentation across agencies and departments, and the need to work together:

“We realize there is so much fragmentation, there is a lack of communication and coordination. People have their missions and they are just following it down without realizing they can get more of their missions accomplished by helping other people accomplish their missions, if we are all working together, whether it’s federal, state or local level. That’s a barrier, a big barrier. We have to get out of our silos.”

-County agency director

Another participant framed the issue from an ecosystem perspective, signifying the importance that decision-makers have the necessary information and education to empower effective action:

“I think the barriers to the process are the standard barriers that anyone who has done any kind of institutional study looking at an ecosystem approach would identify, and that is completely structurally related to... you can trace it right back to how funds are appropriated in Congress. You’ve got these silos that either are agency-wide or within agencies and those are the common barriers we are all working hard to overcome right now. There’s been a lot of strides made, like the restoration initiative, for example, has forced a lot of agencies to work

together that might not have. They're doing it, they're all at the same table, and they're talking about the same things."

– Agency director, basin scale

The need for increased coordination and improved communication spans the local scale to the international scale, as the Great Lakes basin spans both the U.S. and Canada. Concerning leadership,

"The individual has [to have] the vision to see that 'if I participate here or allocate resources here, it will actually meet our mission because we'll accomplish something else that's down the road'. So we have to have the vision, like chess players, to see ten plays beyond where we are."

-Agency director, basin scale

The local to international scale can also be characterized as watershed communities, and is discussed in the following section on watershed scale collaboration.

9.2 Recommendations

- Education of decision makers is critical for effective leadership and improved coordination at all scales. This should take place at the Federal level, as well as the State and local levels, in order to be fully successful.
- Develop communication systems and/or networks that empower professionals to effectively and promptly exchange knowledge and information to facilitate coordinated action.
- Identify areas of weakened authority due to lack of consistent information across departments and agencies, and develop strategies to strengthen institutional framework.
- Ensure that barriers are commonly recognized. Professionals can take more effective action when they are aware a barrier is not a personal failure. Identify tools that will assist professionals to overcome barriers, whether general or issue-specific.

10. Discussion: Watershed Scale Collaboration and Local Governance

10.1 Highlighted Needs

- Coordination: *Information accessibility and distribution: community scale.*
- Policy as barrier: *Remove political barriers to watershed solutions.*
- Social: *Need cultural change, public involvement and leadership.*
- Communication as barrier: *Uncertainty causing distrust of officials.*
- Ecosystem Based Management: *Addressing issues on a watershed scale.*

Current climate change information distributed and made accessible at the community scale was identified as a need in twelve (12) instances. While this information was seen as necessary for policy and planning, barriers were perceived for developing watershed solutions, with political agendas and the political will for action seen as specific local issues (6), as well as any scientific uncertainty, real or perceived, causing distrust of officials (2). Additionally, involving community in decision-making, understanding public perception, having local leadership, and identifying issues based on data were seen as needed for effective climate change planning (5). Each of these needs also fit under the larger umbrella of social and cultural change that is perceived as needed for effective action to occur.

One water manager spoke of the importance of climate impacts on food resources for tribes. As water levels fluctuate or decline, this changes crop yields for wild rice, which is a significant food staple. They had recently undertaken a watershed study to understand the hydrology of the area, and the study was just nearing completion:

“How can we best manage our wild rice lakes based on this watershed model we’ve come up with. It’s actually just starting to be finalized, so we can actually watch this model and see how the water rises and lowers, and that’ll definitely be a good tool to have as the climate changes the hydrology of the area, we’ll be able to monitor those wild rice lakes.”

-Watershed manager

Again, addressing issues on a watershed scale – and even a subwatershed scale - is part of an ecosystem perspective. This perspective was mentioned specifically in two (2) instances as being necessary for long term solutions for adapting to climate change.

“When I am writing watershed action plans—I just finished one for one of our creeks—I definitely included a section about climate change and made that one of the points in the plan and talked to the community partners about that.

“The plan gets revisited after five years and changed as needed and updated, and so the idea is to use adaptive management for the watershed work. So now the vast majority of the watershed has a watershed plan for it. We’ve done it by creekshed by and large, because it would be pretty meaningless to do it for the entire watershed.”

–Watershed planner

In concise terms, this same participant emphasized that climate change:

“is a priority. Things are going to change and we’ve got to get beyond what the cause is and think about some solutions at the local level.”

–Watershed planner

10.2 Recommendations

- Watershed awareness through public outreach campaigns and community involvement practices is a necessary foundation for successful local governance at the watershed scale. Implementing ecosystem based management strategies can be an effective tool at this level, given the trans-boundary nature of watersheds.
- Watershed planning is best done at the sub-watershed scale. Understanding climate impacts specific to the sub-watershed, and consequent impacts on the entire watershed, can be more effective for successful short and long term planning.

11. Planning Timeframes

The time frame most often mentioned (6) as relied upon was five years, followed by six to ten years (4). Categories mentioned at least three times included a 3-year timeframe, 10-year timeframe, and more generally a “reasonable timeframe” to address problems. Several interviewees expressed concern that short term solutions can be a barrier to long-term solutions. One interviewee also mentioned that at the local scale, strong emotional reactions to proposed changes can often guide the decision-making process, which may also hinder implementing long-term solutions.

Each of the following were mentioned two (2) times: following GLRI (Great Lakes Restoration Initiative) funding cycles, one-, two-, and four-year planning horizons, 25- to 40-year planning horizons, long range planning (non-specific), and the general need to have climate change on the planning agenda. One natural resource manager thought that it is necessary to have more information and contemplation of a 100-year scenario to be able to plan effectively. Finally, focusing on climate mitigation can immobilize adaptation planning and was identified as a barrier (4).

“It’d be great to have a 25 year plan to use available funding from the state as well as possibly from the federal government to tackle some of these problems... because we’ve got such a large area and [it] makes up the Area of Concern, and it’s going to take decades to do what we need to do.”

–Watershed coordinator

11.1 Recommendations

- Engaging the community in all stages of planning and decision-making can identify strong perspectives early enough in the process to find solutions all stakeholders can agree upon, thus making long-term solutions more feasible to implement.
- Understand and communicate the differences between climate change mitigation and adaptation, and focus on strategies that lead to action in planning and implementation.

Some actions will integrate both mitigating and adaptive capacities, and are recommended as priority measures for action.

- Two to five year plans were regarded as most effective and actionable. This was also seen as best acted upon when in context of ten to twenty-five years, or even fifty to one hundred years, of long term scenario.

12. Summary of Recommendations

- Planning processes could integrate an ecosystem perspective that makes natural area preservation and restoration a priority to address stormwater runoff, flooding, and development impacts.
- Water treatment systems and built infrastructure operating capacities should be evaluated and modified according to current precipitation trend data.
- Coastal planning has specific infrastructure considerations; soft shore restoration and erosion control strategies can be developed and shared among professional and community networks.
- Education for decision-makers when budgeting for programs. Ensure guidance materials are accessible and up to date for decision-making.
- Education of decision makers is critical for effective leadership and improved coordination at all scales. This should take place at the Federal level, as well as the State and local levels, in order to be fully successful.
- Training and/or resource materials for communication strategies and basic competencies general to climate change awareness as well as issue specific.

- Develop communication systems and/or networks that empower professionals to effectively and promptly exchange knowledge and information to facilitate coordinated action.
- Identify areas of weakened authority due to lack of consistent and reliable information across departments and agencies, and develop strategies to strengthen institutional framework.
- Ensure that barriers are commonly recognized. Professionals can take more effective action when they are aware a barrier is not a personal failure. Identify tools that will assist professionals to overcome barriers, whether general or issue-specific.
- Create watershed awareness through community involvement. Implementing ecosystem based management strategies can be effective at this level, given the trans-boundary nature of watersheds.
- Watershed planning is best done at the sub-watershed scale. Understanding climate impacts specific to the sub-watershed, and consequent impacts on the entire watershed, can be more effective for successful short and long term planning.
- Engaging the community in all stages of planning and decision-making can identify strong perspectives early enough in the process to find solutions all stakeholders can agree upon, thus making long-term solutions more likely to succeed when implemented.
- Understand and communicate the differences between climate change mitigation and adaptation, and focus on strategies that lead to action in planning and implementation. Some actions will integrate both mitigating and adaptive capacities, and are recommended as priority measures for action.
- Two to five year plans were regarded as most effective and actionable. This was also seen as best acted upon when in context of ten to twenty-five years, or even fifty to one hundred years, of long term scenario.

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14. Interview Questions

- 1) Could you briefly describe your work?
 - scope
 - nature
 - decision-making authority
- 2) How does weather impact what you do?
 - Daily, seasonally, annually?
 - Scale of area?
- 3) Would changes in weather or climate effect any built or natural infrastructure that you manage? If so, how?
- 4) What are the planning timeframes used by your agency?
- 5) Do you see a need to expand planning windows in your management or planning strategies?
 - 5a) What would be some of the benefits of this for your work?
 - 5b) What might be some of the barriers to expanding these windows?
- 6) What is your perspective on and understanding of a changing climate in the Great Lakes region?
 - 6a) How do you think a changing climate might effect:
 - Human health?
 - Human safety?
 - Environmental quality?
 - Economy?
 - Property?
 - 6b) Do you think that these impacts would be positive or negative?
 - 6c) Of the negative impacts that have been mentioned, which might inflict greatest losses (economic, social, or environmental)?
- 7) Are there any management or planning actions that directly or indirectly address climate change in your community? If so, what are they? If not, can you foresee an action that would help to avoid future losses, if implemented?
- 8) Is climate change adaptation planning a priority for your community or organization?
 - 8a) (If no) what factors influence or prohibit climate change planning as a priority?
 - 8b) (If yes) If you've been engaged in climate change planning, where is your community in that process?
 - Priority, but no action: What do you need to facilitate your planning?
 - Planning in process: What kind of barriers have you encountered?
 - What resources are currently helpful?
 - What resources or training do you feel are missing?
- ❖ Plan complete: What factors made it successful?
 - What barriers did you encounter?
 - What did you need that was missing?
 - What did you need in technical capacity? Training?

Appendix D: Deliverable 2: NOAA Needs Assessment – Final Report

NOAA Technical Memorandum GLERL-158

PLANNING FOR CLIMATE CHANGE IN THE LAURENTIAN GREAT LAKES BASIN -- A NOAA Needs Assessment - Final Report

Dawn Nelson¹, Heather Elmer², and Patrick Robinson³

¹ University of Michigan School of Natural Resources, Cooperative Institute for Limnology and Ecosystem Research and NOAA, Great Lakes Environmental Research Laboratory

² Old Woman Creek Estuarine Research Reserve, Ohio Department of Natural Resources Division of Wildlife

³ University of Wisconsin-Extension

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UNITED STATES
DEPARTMENT OF COMMERCE

Rebecca Blank
Acting Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

Jane Lubchenco
Under Secretary for Oceans & Atmosphere
NOAA Administrator

This report summarizes the results of a regional assessment to gauge the knowledge, skills, interest, attitudes, and abilities of Great Lakes coastal community planners, stormwater managers, and natural resource managers, in order to design effective training that increases the ability of these groups to confront and adapt to the impacts of climate change.

Funding for this project was received via President Obama's Great Lakes Restoration Initiative. For more information on the Initiative and Action Plan go to www.greatlakesrestoration.us.

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Report prepared for NOAA Great Lakes programs and partners:

Great Lakes Regional Collaboration Team
Ohio Coastal Training Program at Old Woman Creek National Estuarine Research Reserve
Ohio Department of Natural Resources Division of Wildlife
Ohio Coastal Management Program
Lake Superior National Estuarine Research Reserve
Great Lakes Environmental Research Laboratory
Great Lakes Sea Grant Network

This report is a companion document to [NOAA Technical Memorandum 153](#), and the planning needs assessment counterpart to the science needs assessment summarized in [NOAA Technical Memorandum 147](#).

NOAA TM-153. 2011. "Laurentian Great Lakes Basin Climate Change Adaptation" available at: <http://www.glerl.noaa.gov/pubs/techrept.html>.

NOAA TM-147. 2009. "Impact of Climate Change on the Great Lakes Ecosystem a NOAA Science Needs Assessment Workshop to Meet Emerging Challenges – Summary Report" available at: <http://www.glerl.noaa.gov/pubs/techrept.html>.

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NOAA's Mission – To understand and predict changes in Earth's environment and conserve and manage coastal and marine resources to meet our nation's economic, social, and environmental needs

NOAA's Mission Goals:

- Protect, restore and manage the use of coastal and ocean resources through an ecosystem approach to management
- Understand climate variability and change to enhance society's ability to plan and respond
- Serve society's needs for weather and water information
- Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation
- Provide critical support for NOAA's Mission

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Advisors:

Heather Stirratt - NOAA National Ocean Service, Regional Coordinator

Frank Lichtkoppler - Ohio Sea Grant College Program

Pam Kaput - Great Lakes Saint Lawrence Cities Initiative

Susan Lovelace - NOAA Hollings Marine Laboratory

Stephanie Fauver - NOAA Coastal Services Center

TABLE OF CONTENTS

1.	EXECUTIVE SUMMARY	7
2.	LITERATURE REVIEW	8
2.1	Synthesis of Documented Needs	8
3.	METHODS	8
3.1	Data Collection	8
3.2	Target Population	10
3.3	Developing the Top Ten Needs List.....	11
4.	DECISION-MAKER’S BRIEF	11
4.1	Awareness, Attitudes, and Adaptation Activities	11
4.2	Top Ten Needs.....	13
4.3	Needs Fulfillment: NOAA Projects	13
4.4	Priority Recommendations.....	14
5.	ADAPTATION ACTIVITIES.....	15
5.1	Climate Plananing Status	15
5.2	Barriers to and Benefits of Climate Planning.....	16
6.	DISCUSSION: TOP TEN NEEDS	16
6.1	Climate Literacy (Need 1)	16
6.1.1	Self-Assessed Knowledge and Perceived Impact on Work or Decision-Making.....	18
6.1.2	Trusted Information Sources	19
6.1.3	Community Acceptance of Climate Terminology	19
6.1.4	Barriers that Building Climate Literacy could Address.....	19
6.2	Communication, Coordination, and Collaboration (Need 2).....	20
6.3	Financial Resources and Guidance (Need 3)	21
6.4	Maps, Models, Data and Forecasting (Need 4).....	21
6.5	Resilient Land Use Planning (Need 5).....	22
6.6	Regional and Local Climate Data (Need 6).....	23
6.7	Social and Ecological Research and Community Resiliency (Need 7)	23
6.8	Decision-maker Trainings (Need 8).....	23
6.9	Understanding Climate Impacts (Need 9).....	24
6.10	Ecosystem Research and Monitoring (Need 10)	25
7.	NEEDS FULFILLED BY NOAA AND PARTNERS	26
7.1	PCC Workshops	26
7.1.1	PCC Workshops.....	27
7.1.2	Evaluation Surveys and Outcomes	28
7.1.3	Vulnerabilities and Adaptation Options Identified in Workshps	30
7.1.4	Outcomes: Information Sharing, Application to Decision-Making and Management.....	31
7.2	NOAA and Partners	32

8. RECOMMENDATIONS AND NEXT STEPS.....	32
9. REFERENCES	34

LIST OF FIGURES

Figure 1. Highest-rated barriers to climate planning	17
Figure 2. Highest-rated benefits of climate planning.....	17
Figure 3. Degree to which respondents felt informed about climate change issues	18
Figure 4. Degree to which respondents thought climate change would impact their jobs	19
Figure 5. Trust in climate information sources	20
Figure 6. Highest-rated information needs – climate planning.....	25
Figure 7. Highest-rated information needs – climate impacts	26

Planning for Climate Change in the Laurentian Great Lakes Basin A NOAA Needs Assessment - Final Report

D. Nelson, H. Elmer, and P. Robinson

1. EXECUTIVE SUMMARY

The NOAA Great Lakes Regional Collaboration Team, Old Woman Creek National Estuarine Research Reserve and Great Lakes Sea Grant Network, and in collaboration with the Great Lakes and Saint Lawrence Cities Initiative, have worked collaboratively to determine what is needed to increase adaptive capacity in Great Lakes communities to anticipated changes in climate. The primary objective for conducting this study is to increase adaptive capacity by informing and developing climate change adaptation training workshops. To ensure that training meets priority needs and provides accessible and applicable tools and resources, these organizations have collaborated to conduct a needs assessment: a comprehensive front-end evaluation of the climate change adaptation training and information needs of Great Lakes coastal communities. Presented here are the results of a needs assessment completed in 2011, engaging nearly 700 stakeholders across the Basin through interviews, focus groups, and an online survey.

The goal of this needs assessment was to collect sufficient information about the knowledge, skills, interest, attitudes, and/or abilities of Great Lakes coastal community planners, stormwater managers, and natural resource managers to design effective training that increases the ability of these groups to confront and adapt to the impacts of climate change. This study was conducted in two phases with funding from the NOAA Sea Grant Climate Engagement Project for Phase I, a synthesis of existing literature which served to inform the development of the *Climate Ready Great Lakes* training modules¹, as well as a pilot “Train-the-Trainer” workshop held in Michigan for Great Lakes State Sea Grant Extension Agents. Funding from the Great Lakes Restoration Initiative² was utilized for Phase II. This report contains the results of Phase II, a comprehensive data collection coordinated by Old Woman Creek National Estuarine Research Reserve. Study results have informed the development and implementation of specialized training to build the capacity of Great Lakes coastal communities to adapt to the impacts of climate change, with pilot workshops taking place in Ohio, Wisconsin, and Minnesota. Outcomes and evaluation of these workshops are also included in this report.

Study results and recommendations have informed the development of NOAA’s Great Lakes Climate Science and Service Plan³, and will guide future investments by NOAA and other agencies in Great Lakes research, training and decision support services. Training could address issues such as climate change research; long-term forecasts for climate change impacts in the Great Lakes region; processes by which community leaders can identify and consider management responses necessary to respond to forecasted changes; and decision tools and science-based resources that are available to make coastal development, resource protection, and infrastructure decisions today that sustain communities for the next 50-100 years.

¹ NOAA/Sea Grant. 2011. “Climate Ready Great Lakes” training modules are available at: http://www.regions.noaa.gov/great-lakes/?page_id=395.

² Great Lakes Restoration Initiative website: <http://greatlakesrestoration.us>

³ NOAA Great Lakes Climate Science and Service Plan. Personal communication, H. Stirratt, Sept. 7, 2012.

2. LITERATURE REVIEW

2.1 Synthesis of Documented Needs

An initial synthesis of existing literature served to inform data collection, as well as the development of the Great Lakes NOAA/Sea Grant climate adaptation training modules *Climate Ready Great Lakes* (2011)⁴. The literature synthesis is available in the NOAA technical memorandum *Laurentian Great Lakes Basin Climate Change Adaptation* (2011)⁵, and is a companion document to this report. Over 300 needs were culled from existing literature and grouped into five key coastal management issue areas:

- Infrastructure: Ports and Regional Planning
- Water Infrastructure
- Ecosystem Based Management
- Coastal Planning and Management
- Hazard Resilience and Disaster Preparedness

The needs from the 2011 report were further condensed into ten overarching needs, and then revised again once the data collection and analysis were completed to reflect the new information found in the data. This resulted in having a ranked list of the top ten needs for Great Lakes communities to be able to adapt to climate change. This top ten list can be found in this report in the methods section 3.3 and in the results summary chapter, as well as in the NOAA Climate Science and Service Plan for the Great Lakes Region.⁶

3. METHODS

3.1 Data Collection

A three-tier approach for data collection was used to identify information and training needs. Beginning with in-person and telephone interviews, this information influenced the second and third tier of data collection. The second tier included focus groups, and the third tier was an online survey during the months of January and February of 2011.

Data collection for interviews and focus groups took place from July through September 2010. Potential participants for interviews and focus groups were identified through the Ohio Coastal Training Program contact database, the NOAA Sea Grant Extension Agent Network and other NOAA partners. In-person and telephone interviews were conducted across the Great Lakes States, as well as two focus groups in Ohio. Fifteen interviews were conducted in August and September. Focus group participation consisted of one group of four and one group of five. Content analysis of the interviews yielded a ranked list of ten main issue categories, which should be distinguished from the top ten needs list. Detailed results from the interviews and focus groups are supplemental documents to this report, and available on the *Planning*

⁴ NOAA/Sea Grant. 2011. “Climate Ready Great Lakes” training modules are available at: http://www.regions.noaa.gov/great-lakes/?page_id=395.

⁵ NOAA TM-153. 2011. “Laurentian Great Lakes Basin Climate Change Adaptation” available at: <http://www.glerl.noaa.gov/pubs/techrept.html>

⁶ NOAA Great Lakes climate Science and Service Plan. Personal communication, H. Stirratt, Sept. 7, 2012.

for *Climate Change* workshop website.⁷ The top ten needs list was determined from the outcomes of the entire assessment, and is included in the methods section 3.3 and in the results summary chapter of this report.

In January 2011, a web-based survey was constructed to further characterize climate training, information, and data needs identified through literature review, interviews, and focus groups. The survey was designed by a project team including staff from Old Woman Creek and Lake Superior National Estuarine Research Reserves, Ohio Sea Grant College Program, the Great Lakes Saint Lawrence Cities Initiative, and the NOAA Great Lakes Regional Team with technical guidance from social scientists at the NOAA Hollings Marine Laboratory, NOAA Coastal Services Center and professional staff of the Ohio and New York Coastal Management Programs. The project team utilized other needs assessment surveys designed to identify climate training and information needs of municipal officials throughout the country as prototypes (Angell, 2008; Auermuller, 2011; Tribbia and Moser, 2008, Krum and Feurt 2002, Pollack and Szivak, 2007). The survey consisted of 22 questions designed to assess:

- Self-reported awareness of climate change causes, impacts, mitigation and adaptation options
- Trusted sources of climate information
- Perceived impact of climate change on work or decision-making
- Climate planning initiatives underway
- Perceived acceptance of climate-related terms among peers or colleagues
- Perceived barriers to and benefits of climate planning
- Need for information and tools

The survey was disseminated by e-mail to a target population of Great Lakes decision-makers through NOAA state partner program networks including mailing lists of the Old Woman Creek and Lake Superior National Estuarine Research Reserves, Minnesota, Pennsylvania and Ohio Sea Grant Programs; and Ohio, Michigan, New York, and Wisconsin Coastal Management Programs. Professional associations were also asked to assist with survey dissemination.

Survey results were analyzed by the Great Lakes Environmental Finance Center at Cleveland State University. The survey results are discussed in detail in the report “Climate Change Needs Assessment Survey Analysis”, including an evaluation of variability among respondent subgroups by State, sector, and planning stages.⁸ All five Lake basins are represented in the study results. Key variations in data are noted where applicable (i.e., by sector or geographic region).

This document contains survey results for a benchmark group of respondents that identified themselves as working within one or more Great Lakes Watersheds. This group of respondents is referred to as the *Great Lakes Benchmark Group*. In the detailed analysis, a t-test was used to compare mean values for subgroups determined by geography or sector to the remainder of the Great Lakes Benchmark Group. For that analysis, alpha levels for the t-test were converted into descriptive wording as follows: statistical

⁷ All needs assessment and workshop materials are available at: <http://nerrs.noaa.gov/CTPIndex.aspx?ID=663>

⁸ The Great Lakes Environmental Finance Center. Maxine Good an Levin College of Urban Affairs Cleveland State University, 2011. “Climate Change Needs Assessment Survey Analysis” Principal Author: Charlie Post. Available at: <http://nerrs.noaa.gov/CTPIndex.aspx?ID=663>.

significance at the 0.1 level is termed “somewhat different”, at the 0.05 level it is termed “different”, and at the .01 level it is termed “extremely different”. A total of 785 people started the survey, and 609 completed it. Incomplete surveys were included in this analysis and therefore the sample size for statistical analysis varies by question. The Great Lakes benchmark group ranged in size from 530 to 669 across all questions in the survey.

3.2 Target Population

The target population was professional planners, stormwater managers, natural resource managers, public health officials, and emergency managers working in Great Lakes coastal counties or watersheds. There are 158 coastal US counties, 121 watersheds, and thirteen major urban areas in the Great Lakes basin.⁹ A breakdown of specific professional roles targeted for this survey is detailed in the following section.

Planners

- Professional Planner - land use, transportation, ports, energy, water infrastructure
- Sustainability Director
- Zoning Director/Administrator
- Director of Housing and Business Development
- Energy Procurement Manager

Stormwater Managers

- Public Works Director
- Engineer
- Public Service Director
- Permitting Authorities
- Municipal Separate Storm Sewer System (MS4) Program Coordinators
- Stormwater Plan Reviewers

Natural Resource Managers

- Parks and recreation directors
- City Forester
- Park and protected area managers at the local, state, and federal levels

Policy-Makers

- City Council members
- Township Trustees
- Mayors
- County Commissioners
- State Representatives
- Representatives and Staff on State Legislature Natural Resource and Environment committees
- Staff on State Departments of Natural Resources and Environmental Quality Protection

Emergency Managers

- County Agency Director

⁹ NOAA’s State of the Coast. The U.S. Population Living in Coastal Counties: Available at: <http://stateofthecoast.noaa.gov/population/welcome.html>.

- Municipal Manager
- Water Manager
- Emergency Management Director
- Public Health and Safety Director

3.3 Developing the Top Ten Needs List

Drawing from the review of literature, as well as from the insights of almost 700 Great Lakes coastal community decision-makers, it was possible to develop a prioritized list of the top ten needs for Great Lakes communities to be able to adapt to climate change. The ranking of these ten needs was developed by grouping the over 300 needs identified in the literature review¹⁰ into ten overall categories.¹¹ These categories were then prioritized based on the number of times they appeared in the literature review. This prioritization of needs documented in existing literature was then updated, enhanced, and expanded in descriptive detail to incorporate new information gathered on regional needs through interviews, focus groups, and an online survey, resulting in the final prioritized list presented on the next page.

4. DECISION-MAKER'S BRIEF

4.1 Awareness, Attitudes and Adaptation Activities

Awareness of climate change and impacts varied across the basin. While it is often assumed that public awareness of climate change is low, several participants exhibited high-level awareness. Many participants felt well informed on climate change issues and were able to speak knowledgeably about perceived impacts, as well as identify specific tool and information needs, whether for professionals, the public, or policy-makers, in order to effectively anticipate and adapt to climate impacts. However it should be noted that within the survey population there was a small group of respondents that indicated that they think climate change is unproven. Another small group (which may overlap the first one) believed that it is important to distinguish between natural and human causes of climate change. This group seemed to acknowledge that climate change is occurring, but that it isn't caused by humans.

Participants felt that education for decision-makers was a priority need and having high-level advocacy for climate change issues would enable and facilitate effective planning at all scales. Uncertainty about climate impacts and how to communicate impacts to the public was listed as a potential barrier, with the potential to instill or increase mistrust of government officials.

Having near and far term trend reports for lake level fluctuation and changes in weather patterns could be used to inform planning and decision-making. Understanding how the natural system has behaved historically and how the natural systems are changing from historical trends can be achieved by maintaining monitoring systems that inform regionally specific climate and hydrological model outputs. Participants believed that having this type of information would be very helpful to justify decisions and actions.

¹⁰NOAA TM-153. 2011. "Laurentian Great Lakes Basin Climate Change Adaptation" available at: <http://www.glerl.noaa.gov/pubs/techrept.html>

¹¹ Credit for this work is given to contributing author Brent Schleck, who analyzed the literature synthesis and developed an initial list of the top ten needs. The final list of needs presented in this report is shaped by the work performed to develop the overall prioritization and structure of categories.

Top Ten Needs (detailed list)

1. Increase climate change literacy through research that addresses decision-maker needs, comprehensive science education throughout all grade levels, community outreach, ensuring ecological awareness through youth programs as well as training students in scientific field methods, tribal engagement, increased communication with stakeholders, and end-user/public participation. Build climate literacy within NOAA, strengthen internal agency capacity to deliver climate services, and develop public awareness of NOAA climate services.
2. Regional needs coordination and relationship building between organizations at the federal, state, and local levels for the sake of efficient knowledge exchange through improved communication, decreased redundancy, and reduced regulatory/cross-jurisdictional conflicts.
3. Financial support, as well as political guidance and resource leverage for local climate adaptation efforts / projects.
4. Management, coordination, and adjustment of maps, models, and collected data to incorporate new information and to allow for regional, as well as downscaled forecasting, analysis, and assessment of climate change related events.
5. Research and implementation of resilient land use and physical planning/design that incorporates local economic drivers, infrastructure management/monitoring, transportation, and land-sea interactions. Document implementation challenges and successes to support diffusion of knowledge and adaptive planning and management across the region.
6. Engage states, municipalities, and managers (e.g. land use planners, emergency managers, and extension agents) in collaborative research to generate current, comprehensible, near-term, and regionally relevant climate change data to inform decision-making (e.g. drafting ordinances, master plans, and evacuation plans).
7. Engineering, design, and social research as it applies to data collection methods, modeling, forecast uncertainty, extreme event attribution, and community resiliency.
8. Decision maker trainings revolving around utilizing sector-specific, as well as general tools/strategies to implement clear and flexible ecosystem-based management programs that properly manage/protect resources (e.g. forests, fisheries, beaches, floodplains).
9. Assessing the impacts of climate change on natural resource demands / budgets, and how those impacts will affect different sectors of the economy.
10. Biological/ecological research, assessment, and monitoring, as well as prioritization of ecosystem preservation, in order to mitigate environmental stressors and monitor ecosystem health.

In the survey, 70% of Great Lakes benchmark respondents perceived planning and policy guidance as a barrier to climate planning. The most significant benefit of climate planning for the Great Lakes benchmark survey group was improved quality of life for future generations, which was seen as a significant benefit by 70 percent of the respondents. Improved environmental quality and a more secure water supply were perceived as the next most significant benefits of climate planning. Additionally, perceived benefits included increased opportunities for renewable energy, and a more pleasant climate for the region. With this understanding, having a comprehensive social and ecological picture of possible climate scenarios could enable communities and policy-makers to more fully recognize and actualize opportunities and to mitigate impacts.

4.2 Top Ten Needs

Top Ten Needs in Brief

1. **Climate Literacy.** Increase climate change literacy through research that addresses decision-maker needs, comprehensive science education throughout all grade levels, and informal science education for the public.
2. **Regional Needs Coordination.** Build relationships between organizations at the federal, state, and local levels for the sake of efficient knowledge exchange.
3. **Financial Resources and Guidance.** Resource leverage for climate adaptation.
4. **Information Tools.** Management, coordination, and adjustment of maps, models, and collected data to incorporate new information and to allow for regional forecasting, analysis, and assessment of climate change related events.
5. **Resilient Land Use Planning.** Research and implementation of resilient land use and physical planning/design that incorporates local economic drivers, infrastructure management/monitoring, transportation, and land-sea interactions.
6. **Climate Change Data.** States, municipalities, and managers need current, comprehensible, near-term, and regionally relevant climate change data to incorporate into decision-making (e.g. drafting ordinances, master plans, and evacuation plans).
7. **Social and Ecological Research and Community Resiliency.** Engineering, design, and social research as it applies to data collection methods, modeling, forecast uncertainty, extreme event attribution, and community resiliency.
8. **Decision-maker Trainings.** Trainings utilizing sector-specific and general strategies to implement clear and flexible ecosystem-based management programs.
9. **Understanding Climate Impacts.** Assessing the impacts of climate change on natural resource demands and budgets, including differential impacts across sectors.
10. **Ecosystem Research and Monitoring.** Biological and ecological research, assessment, and monitoring, as well as prioritization of ecosystem preservation, in order to mitigate environmental stressors and monitor ecosystem health.

4.3 Needs Fulfillment: NOAA Projects

The Ohio Coastal Training Program at Old Woman Creek National Estuarine Research Reserve and the Lake Superior National Estuarine Research Reserve coordinated a regional project to customize *Planning for Climate Change*, a one-day training workshop to address Great Lakes issues and the needs of planners and other professionals working on land use, public health, stormwater, emergency preparedness, and natural resource management issues across the region.

Old Woman Creek and Lake Superior National Estuarine Research Reserves convened three planning teams which used the results of this assessment in concert with local knowledge of needs and climate resources to customize a NERRS *Planning for Climate Change* workshop to meet the needs of Great Lakes professionals and decision-makers. The one day training increases participant understanding of climate science and regional vulnerabilities and builds local capacity for adaptation including awareness of best available local and regional data, planning process, resources, and adaptation strategies, and tools for stakeholder engagement.

Along with the *Planning for Climate Change* workshops, NOAA and Sea Grant have also developed training modules to assist communities in planning for and adapting to climate change. The *Climate Ready Great Lakes* ‘train the trainer’ training modules¹² include three modules that can be presented as single modules, or as a group. The first module, “*What am I adapting to?*” addresses climate impacts and explains the science of climate change. The second module, “*What is an adaptation plan?*” instructs trainers on how they can engage the community to develop a tailored plan for adapting to climate change. The third module, “*What tools are available to me?*” includes a review of available tools to assist in decision-making. Each of these modules are customizable and come with supplemental materials for trainers to use.

In addition, the NOAA Coastal Services Center has developed *Climate Adaptation for Coastal Communities*, a three-day course that builds participant understanding and skills related to climate science and impacts; community vulnerability assessment; effective communication; identification and implementation of adaptation strategies. Opportunities for local collaboration and next steps for adaptation planning and implementation are emphasized through discussion, participant activities, and incorporation of local speakers and examples. The course is designed for program administrators, land use planners, public works staff members, floodplain managers, hazard mitigation planners, emergency managers, community groups, members of civic organizations, and coastal resource managers.

Additionally, NOAA provides operational support for two climate centers located in the Great Lakes region including the Midwestern Regional Climate Center (MRCC) and the Northeast Regional Climate Center (NRCC). The MRCC and the NRCC provide services and outreach to their regions to better explain climate impacts, provide practical solutions to climate problems, and to develop climate information regarding regionally significant sectors that climate change will affect (e.g. agriculture, energy, environment, public health, transportation, and water resources). In total there are six Regional Climate Centers operating nation-wide.

NOAA’s Regional Climate Centers (RCCs) are a federal-state cooperative effort. The RCC Program is managed by the NOAA’s National Climatic Data Center (NCDC). NCDC’s Regional Climate Centers support a three-tiered national climate services support program in partnership with other agencies including the [National Weather Service](#) and [State Climate Offices](#)¹³

4.4 Priority Recommendations

Whereas many of the top ten needs are being addressed by current projects, there still remain unmet needs that can, in part, be addressed by making the following recommendations a priority for decision-making:

- Continue and expand delivery of climate adaptation training at the community level throughout the Great Lakes region. Engage end users in collaborative research and climate service development to leverage the wealth of knowledge and local expertise across the region.

¹²The “Climate Ready Great Lakes” training modules are available at: http://www.regions.noaa.gov/great-lakes/?page_id=395.

¹³Midwestern Regional Climate Center website <http://mcc.sws.uiuc.edu/overview/overview.htm> and NCDC Website <http://www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html>

- Develop educational tools and resources to increase understanding of climate impact scenarios that include modeling output and anticipated trends for natural, social, and economic systems. Having a comprehensive social and ecological picture of possible climate scenarios will enable the public and policy-makers to more fully recognize, anticipate, and actualize opportunities and mitigate hazards. Determine regionally specific ‘no-regrets’ policy options for each of the Great Lakes, and as a collective.
- Increase capacity for local and regional monitoring of the Great Lakes, as well as the coastal watersheds. Develop partnerships to collect and analyze data. Further develop and strengthen regionally coordinated efforts to maintain monitoring systems. Educate policy-makers on the need for funding the implementation and maintenance of large lake observation systems.
- Develop partnerships and regionally coordinated efforts to leverage funding for large-scale projects. Strengthen communication with policy-makers and include specific cost-benefit analyses for anticipated improvements.

5. ADAPTATION ACTIVITIES

5.1 Climate Planning Status

About 25 percent of respondents in the Great Lakes benchmark group indicated that planning was at least underway in their community or organization: 21% indicated that planning was underway, 1% indicated that planning is complete, and 3% indicated that planning is complete and implementation is underway. Within the other 75%, 32% indicated that planning was not underway but conversations have begun, and 43% indicated that nothing has happened. The top three steps taken were “initiated public discussion,” “conducted background research,” and “convened working group.” At least two of these three steps were also among the top three for most subgroups. Other steps which ranked in the top three for individual subgroups were “contacted specialist for information/assistance,” “participated in clean energy initiatives,” “assessed climate change impacts on ecosystems,” and “climate change impacts have been addressed through the existing planning process” and “assessed climate change impacts on infrastructure.”

The following entities’ climate planning efforts were identified as models:

- Cities: Ann Arbor, Michigan; Cincinnati, Ohio; Cleveland, Ohio; Chicago; East Lansing, Michigan; New York City; Portland and Seattle (state not indicated); Portland, Oregon; and Town of Sandy Creek
- States: Arizona, California (mentioned four times), Delaware, Maryland, Michigan (mentioned twice), New Jersey; Wisconsin (mentioned twice), and “other states” (mentioned three times)
- Centers for Disease Control and Prevention (CDC) Climate Ready States and Cities Initiative, Corps of Engineers partnering with other agencies (National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey, U.S. Environmental Protection Agency, etc.), Department of Interior, Federal Highway Administration, All Great Lakes Coastal Management programs, National Park Service, and NOAA.
- Universities: Penn State, University of Wisconsin
- Others: Chicago Climate Action Plan; Chicago Wilderness Adaptation planning process; Delaware Valley Regional Planning Commission, Philadelphia, Pennsylvania (mentioned twice); Forest

Service; MGA; Michigan Climate Coalition; Nature Conservancy; Northeast States for Coordinated Air Use Management/Regional Greenhouse Gas Initiative (NESCAUM/RGGI); Federal: American Association of State Highway and Transportation Officials (AASHTO), public utility commissions, including California; Sustainable Twin Ports group (based on Natural Step program from Sweden); Toledo Metropolitan Area Council of Governments; and Wisconsin Initiative on Climate Change Impacts (mentioned twice).

A small subset noted elements of their organization’s climate planning that they felt were exceptional. Responses generally fell into the following categories:

- Thirteen cited their efforts to reduce greenhouse gases and develop alternative energy sources.
- Eight pointed to their work on storm water management plans, wetlands and/or coastal areas, or other water-related issues.
- Seven cited their work in habitat preservation or restoration, and/or mitigation of the impact of climate change on species.
- Other answers included collaborative work with other agencies or community groups, implementation of statewide recommendations or action plans, and the protection of human health through adaptation.

Some respondents noted that their community or organization is conducting research or monitoring related to climate change including monitoring of water systems, researching the effects of climate change on local species, and studying energy issues and greenhouse gas emissions. Some respondents noted that they relied on or contracted with other entities to provide research on the impact of climate change and others cited the integration of their data into regional networks.

5.2 Barriers to and Benefits of Climate Planning

For the Great Lakes benchmark group, the most significant barrier to climate planning was funding, which was seen as a significant barrier by 78% of the respondents. Next was staff time, which was seen as a significant barrier by 60%, and then political support (58%). The highest percent response for “not a barrier” was for technical capabilities (12%), followed by facilitation assistance (11%), and access to data and information (10%).

The most significant benefit of climate planning was improved quality of life for future generations, which was seen as a significant benefit by 70% of Great Lakes respondents. Next was improved environmental quality, which was seen as a significant benefit by 66%, and then a more secure water supply (64%). The highest percent response for “not a benefit” was for compliance with federal and state mandates (15%), followed by job creation (14%), and meeting political and public demand (12%) (Figures 1 and 2).

6. DISCUSSION: TOP TEN NEEDS

6.1 Climate Literacy (Need 1)

Awareness of climate change and impacts varied across the basin. While it is often assumed that public awareness of climate change is low, several participants exhibited high-level awareness. Many participants felt well informed on climate change issues and were able to speak knowledgeably about perceived impacts, as well as identify specific tool and information needs, whether for professionals, the public, or policy-makers, in order to effectively anticipate and adapt to climate impacts.

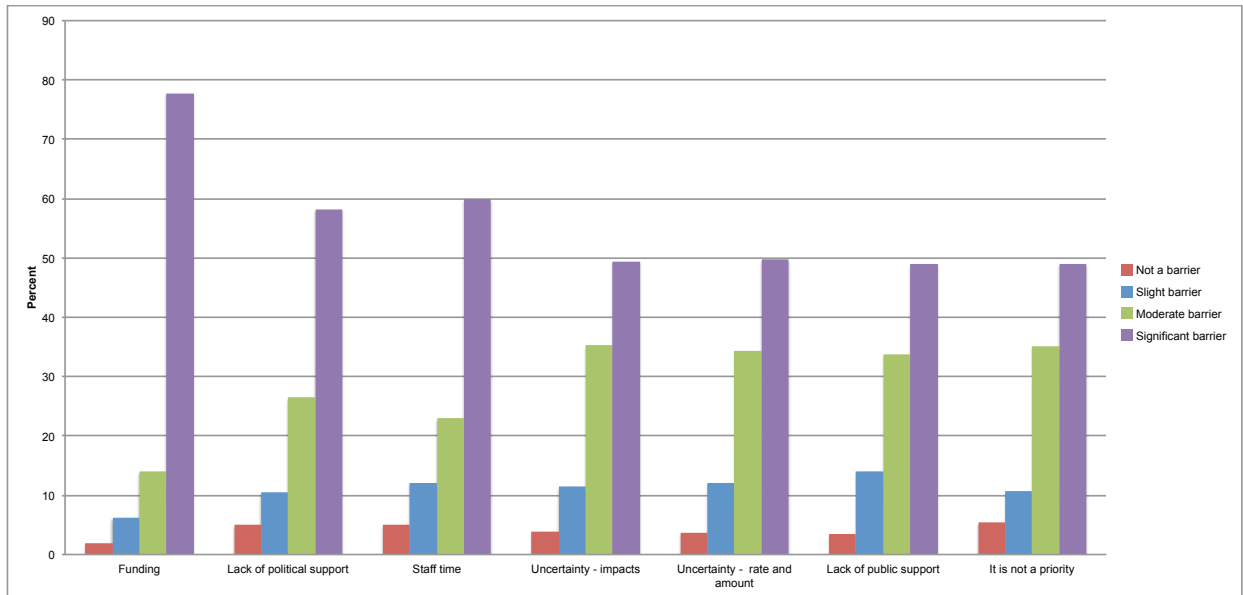


Figure 1. Highest-rated barriers to climate planning.

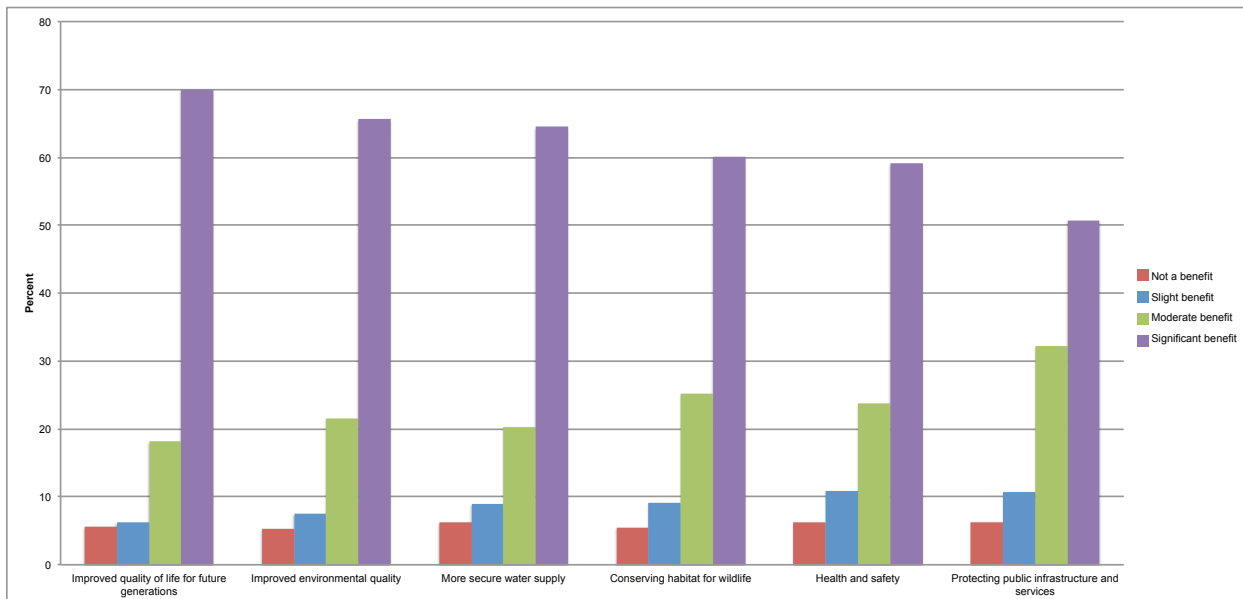


Figure 2. Highest-rated benefits of climate planning.

Participants who felt that they were not very well informed were able to identify more general types of information they needed, such as changes in rates of precipitation and anticipated climate scenarios, in order to make decisions with more certainty.

In the interview data, uncertainty about climate impacts and how to communicate impacts to the public was listed as a potential barrier, with the potential to instill/increase mistrust of government officials. Participants felt that education for decision-makers was a priority need and having high-level advocacy for climate change issues would enable and facilitate effective planning at all scales. Interview data also showed that public education and comprehensive science education was regarded as a priority need and ranked fifth in the ten issue categories.

Participants in the focus groups were able to speak very specifically to concerns about flooding as it impacts water infrastructure, as well as personal property and coastal development. Often mentioned was the need for public education on fluctuating lake levels and long-term coastal impacts, as well as water flow to the lake from onshore systems. A big concern across the two groups was effectively communicating about climate impacts, as discussion about climate change is not socially acceptable in many communities. Strategies for communicating about uncertainty in climate change were identified as an important need in each focus group, as well as in several of the interviews. Other topics identified for public education were stormwater management, water treatment, sanitary sewers, rain gardens and barrels, swales, stormwater basin retrofits and maintenance, and stream restoration.

However, as mentioned previously, it should be noted that within the survey population there was a small group of respondents that indicated that they think climate change, or at least human-caused climate change, is unproven.

6.1.1 Self-Assessed Knowledge and Perceived Impact on Work or Decision-Making

Twenty four percent of Great Lakes benchmark group respondents to the survey indicated they were “very well” informed about the *causes of climate change*, 20% about *ways to reduce climate change*, 17% about *climate change* in their region. Eleven percent were “very well” informed about *ways to prepare for the impacts of climate change*. The highest percent response for “not at all informed” was for ways to prepare for the impacts of climate change (5%), while the rates for the other three topics were all under 2% (Figure 3).

About 70% responded that climate change will impact their job either “a great deal” or “moderate amount” with about 26% responding a “great deal” and approximately 13% indicated “not at all” (Figure 4).

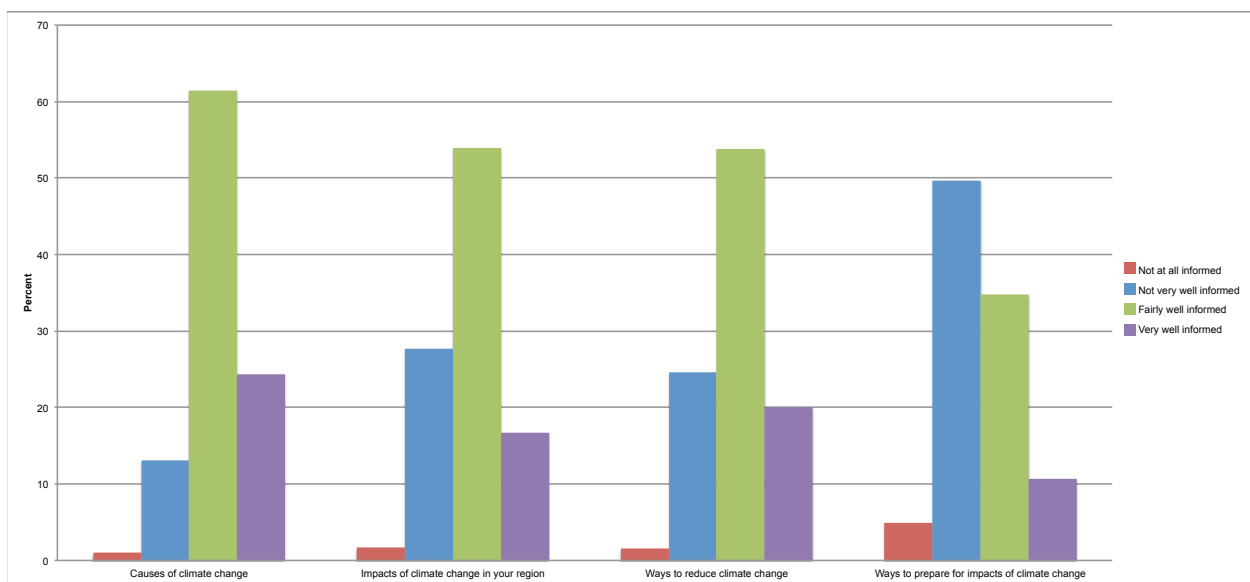


Figure 3. Degree to which respondents felt informed about climate change issues.

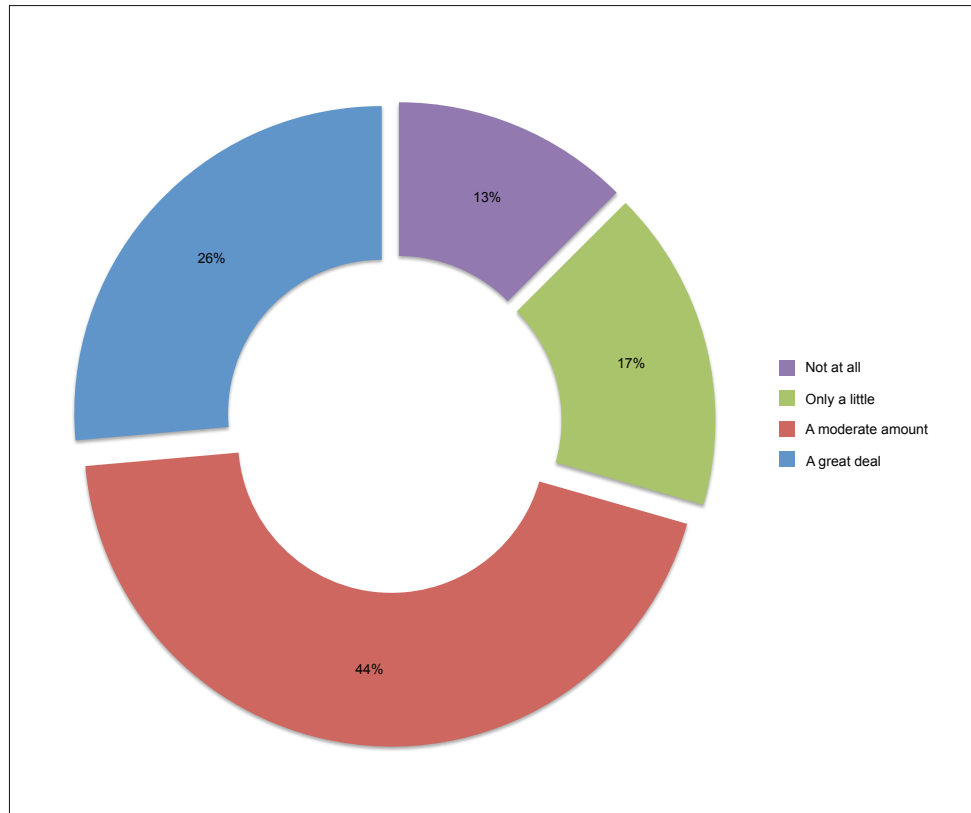


Figure 4. Degree to which respondents thought climate change would impact their jobs.

6.1.2 Trusted Information Sources

The three most “strongly trusted” sources were peer reviewed journals (54.4%), university scientists (52.0%), and conferences and symposiums (34.1%) The three most “strongly distrusted” sources were television (19.1% of respondents), radio (14.4%), and (tie) internet (13.4%) and newspapers (13.4%) (Figure 5).

6.1.3 Community Acceptance of Climate Terminology

The term “climate change” was “highly accepted” by 14 percent of respondents, “community sustainability” by 10%, “hazard mitigation” and “global warming” by 7%, and other climate change related terms were highly accepted by less than 4%. The highest percent response for “highly unaccepted” was for “global warming” (7%), and the next highest was for “climate change” (4%).

6.1.4 Barriers that Building Climate Literacy Could Address

Eighty five percent of Great Lakes benchmark respondents identified lack of political support as a barrier to climate planning. Eight two percent identified lack of public support as a barrier, and 81% indicated that denial that climate change is happening or a problem is also a barrier. Sixty seven percent identified lack of agency/organizational support. About eight survey respondents indicated that they would like better information that is easier to present to and be understood by the general public, and tailored to the specific (often local or regional) audience.

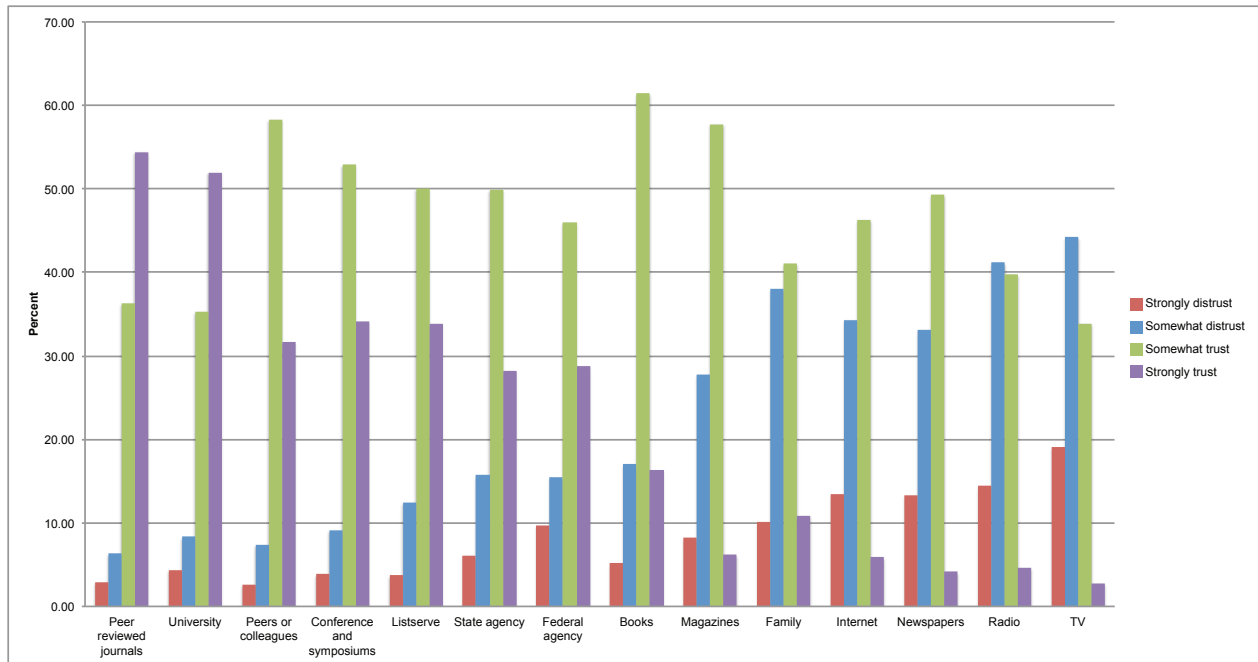


Figure 5. Trust in climate information sources.

6.2 Communication, Coordination, and Collaboration (Need 2)

The need for improved coordination between levels of government and with other agencies, and specifically across jurisdictional boundaries, ranked second in the ten issue categories identified in the interview phase of the needs assessment. Fragmentation in government was seen as a significant barrier, along with mistrust of officials. Strategies for communicating about uncertainty in climate change were identified as an important need in each focus group, as well as in several of the interviews. Other coordination issues identified were information accessibility and distribution at the community scale, and the need for demonstrated leadership at all levels. For example, one participant spoke of the changes in public health agencies after September 11, 2001. After this tragedy occurred, public health departments and related agencies improved service and response time through more integrated coordination that recognized public health agencies as *the lead agency*. This emphasizes the need to have clear understanding of which agency is in the lead of a coordinated effort for the effort to be most effective. Additionally, lack of regional coordination across city or county boundaries can make it difficult to address flooding issues for a watershed system in its entirety. Participants in each focus group identified the need for regional coordination, as well as the barriers to coordination. Participants believed that municipalities are often hesitant to yield decision-making authority to regional water sewer district service management as the trade-off for a regional water system. However, the value of a regional stormwater utility was regarded as a beneficial improvement.

“People have their missions and they’re just following it down without realizing that they can get more of their missions accomplished by helping other people to accomplish their missions, if we are all working together – whether it’s federal, state, or local level.”

– County Agency Director (from interviews)

In the survey, 67% of Great Lakes benchmark respondents identified lack of cooperation and coordination between agencies and organization as a barrier to climate planning. Respondents in the Federal

Government, Regional Government, and All Great Lakes subgroups were significantly less likely to identify cooperation and coordination as a barrier. Sixty three percent saw lack of facilitation assistance as a barrier to climate planning.

6.3 Financial Resources and Guidance (Need 3)

In the survey, financial assistance and/or incentives for adapting to climate change was most frequently identified by Great Lakes benchmark respondents as an area where they need ‘a lot more information’ (57%). About 92% responded that funding is either a “moderate barrier” or a “significant barrier,” including 78% as “significant.” The Federal Government and All Great Lakes subgroups were less likely to see funding as a significant barrier to climate planning.

The most frequently identified factor limiting access to tools for climate planning was staff time (74%), followed by funding (68%), knowledge about tools (63%), technical capacity (49%), and access to data (35%). Use of tools for climate planning was relatively low for the Great Lakes benchmark group. Sixty three percent indicated that they do not use decision support tools, 62% do not use forecast models, 59% do not use stakeholder engagement processes, 53% do not use database management, 41% do not use GIS, and 39% do not use maps. Respondents were most likely to draw on outside expertise for forecast models (23%), and least likely for stakeholder engagement processes (14%).

Focus group discussion about water infrastructure improvements highlighted the need to leverage resources for large-scale, expensive projects with very local implications. Such expensive projects often leads to inaction and failing infrastructure, as participants talked about the difficulty in justifying budgets with perceptions of uncertainty in climate planning. Several city officials discussed the magnitude of the issue:

“Typically several million dollars of work annually, on the average in ..., doing sewer separation projects, separating storm and sanitary sewers, trying to reduce inflow and infiltration, reduce, we have very big basement flooding problems in our city.”

–Municipal Engineer (during focus group)

“We have some water lines or sewer lines that are 100 years old or more and never planned for any replacement. When you approach the people, the people want the replacement, but the city has not set aside funds so it’s either people have to be assessed, and no one wants to be assessed or they expect the city to pay for it, which would mean grants. It’s a gigantic problem.”

– City Mayor (during focus group)

Concerning funding for ecological restoration projects, interview participants perceived lack of funding as a barrier, although this barrier was somewhat mitigated by having near and long term planning goals and scoped projects already identified on paper, which can be undertaken as soon as funding becomes available. Interviewees also believed having decision support for program budgeting was needed.

6.4 Maps, Models, Data and Forecasting (Need 4)

In the focus groups, there was general awareness of changes in precipitation as something associated with climate change. Descriptions of heavy and/or torrential rain as a more regular occurrence, and the consequent impacts on water infrastructure generated discussion on stormwater management and methods

for managing increased amounts of water, such as with retention basins or with green infrastructure and low impact development. Participants identified rain barrels, rain gardens, and other GI/LID strategies as possible solutions. Also mentioned were the increasing costs incurred by cities for maintenance and/or emergency services. There was very clear awareness of precise changes in precipitation patterns based on long-term personal observations. Specific concern was expressed for the need for weather gauges and monitoring stations locally, as discussion centered on how dramatically different microclimates can be within close proximity of each other. For example, one infrastructure manager stated that:

“We’re gathering long-term control plan data right now, and even in our little tiny area we put up 3 rain gauges. So in 5 square miles we decided we might have 3 distinct weather patterns.”

– Municipal Water Infrastructure Manager (during focus group)

Similarly, more consistent collection of stream data was mentioned as needed to inform stream models, and especially urban streams. This was mentioned in both the focus groups and in several of the interviews.

“What’s hard is that people are going to ask the inevitable question what am I planning for? More rain? Less rain? More snow? less snow?”

–Stormwater manager (during focus group)

In the survey, 85% of the Great Lakes benchmark group indicated that the level of uncertainty about the impacts of climate change was a barrier to climate planning, 84% uncertainty about the rate and amount of climate change, 83% uncertainty about adaptation options, and 82% regarding uncertainty about mitigation options.

6.5 Resilient Land Use Planning (Need 5)

As mentioned in the previous section, there was general awareness of changes in precipitation as something associated with climate change among focus group participants. Descriptions of heavy and/or torrential rain as a more regular occurrence, and the consequent impacts on water infrastructure generated discussion on stormwater management and methods for managing increased amounts of water, such as with retention basins. Also mentioned were the increasing costs incurred by cities for maintenance and/or emergency services. It was noted that it is problematic to deal with issues as costly emergencies, rather than to anticipate the issue and manage it before it occurs. One city forester talked about how much it costs the city to deal with downed trees after a storm, when it would be much less if there were routine maintenance for trimming tree branches. Discussion on flooding as it impacts personal property was considered an important issue and challenging problem. Flooding was talked about as a major concern for property owners, as well as a challenge for regional coordination, as discussed previously in section 6.2. In the interview data, both water quantity and quality ranked high on the issue list, along with the need for ecosystem-based management strategies for habitat and natural area preservation. Coastal planning for lake level changes and resilient coastal infrastructure was discussed across nearly all of the interviews. The need for decision support resources that identify and characterize anticipated climate impacts was discussed in the context of understanding the implications for development projects. Being able to address issues on a watershed scale was also a concern.

In the survey, “Lessons learned from communities that have taken action” and “Examples of how Great Lakes and other communities are preparing for climate change” ranked second and third among 22 issue areas in which Great Lakes benchmark respondents need “a lot more information” to effectively do their jobs. 83% of survey respondents perceived protecting public infrastructure and services as a benefit of climate planning.

6.6 Regional and Local Climate Data (Need 6)

Participants in both focus groups and interviews talked about the need for updated precipitation data that reflect trends from recent years and forecasted rates. Having information on storm classifications was also mentioned, as well as guidance documents on anticipated climate impacts. Several engineers felt that having design standards based on current precipitation data and forecasts of future rates is critical to design stormwater infrastructure at an effective scale that can handle any anticipated increases in the intensity of rainfall. Several participants believed that strengthening professional networks and intranet communication systems would facilitate the exchange of knowledge and information, and that local information should be made accessible and distributed at the community scale. In the survey, 61% of the Great Lakes benchmark respondents perceived access to data as a barrier to climate planning.

6.7 Social and Ecological Research and Community Resiliency (Need 7)

There was also discussion on how water levels might be affected from engineered systems, such as dams, and how this might complicate anticipating water level changes. Focus group participants regarded having information about regionally relevant engineered systems as an important piece to understand lake level fluctuation. Additionally, modeling potential shifts in shipping activity based on anticipated lake levels and the estimated ability to maintain ports and harbors (e.g., dredging) could assist communities in making long term plans and decisions that may mitigate economic losses.

Concerns about water temperature increase and resulting consequences on ecosystems and duration of ice cover were identified in several of the interviews. Economic concerns included potential impacts from aquatic invasive species on food webs and commercial and recreational fishing that could detrimentally affect current fishing practices, and that beach health hazards and fish kills could compromise the quality of beaches and deter tourists. Changes in shipping seasons, capacity, and navigation were discussed across several of the interviews as having potentially severe implications for local and regional economies, as well as presenting financial challenges for management of navigation channels and dredging projects. Participants felt that not being able to maintain ports, harbors and marinas could result in economic loss from reduced shipping activity regionally and from international import and export, as well as from impacts on recreational boating.

In the survey, 70% of Great Lakes benchmark respondents perceive planning and policy guidance as a barrier to climate planning. The most significant benefit of climate planning for the Great Lakes benchmark survey group was improved quality of life for future generations, which was seen as a significant benefit by 70% of the respondents. Next was improved environmental quality, which was seen as a significant benefit by 66 percent, and then a more secure water supply (64%).

6.8 Decision-maker Trainings (Need 8)

Leadership training, as well as improved coordination across jurisdictional and sectoral boundaries, was seen as an important priority across many of the interviewees and in the focus groups. Fragmentation in government was considered one of the most significant barriers to development of policies or plans for

climate change. Uncertainty about climate impacts and how to communicate impacts to the public was identified as a potential barrier, with the potential to instill or increase mistrust of government officials. Participants felt that education for decision-makers and having high-level advocacy for climate change issues would enable and facilitate effective planning at all scales.

In the survey, 45% of Great Lakes benchmark respondents were “very interested” in obtaining climate change knowledge and planning skills in a fact sheet format, 44% through one day intermediate training workshops, and 40% through websites. The format for which the highest percentage of respondents were “not interested at all” was multi-day advanced training courses (29%).

Of 22 issue areas, Great Lakes respondents most frequently identified financial assistance and/or incentives for adapting to climate change as an area where they need ‘a lot more information’ (57%). Next was lessons learned from communities that have taken action, which was selected by just over 53%, and then examples of how Great Lakes and other communities are preparing for climate change (just under 53%). The highest percent response for “do not need any information” was for the science of climate change (20%), followed by scientific projections of climate change phenomena such as temperature rise, precipitation, and lake level - nationally (18%), and potential impacts of climate change - nationally (16%) (Figure 6).

Of 25 potential climate change impacts, respondents most frequently selected impacts on the economy as an area where they need “a lot more” information (31%). Next was ecosystem restoration, creation, and enhancement, which was selected by 30%, and then ecosystem protection and management (29%).

6.9 Understanding Climate Impacts (Need 9)

Reduced uncertainty regarding anticipated impacts was a primary concern across focus groups and interviews. Many participants felt that it is extremely difficult to justify budgeting resources to address potential issues without having more certainty about projected impacts. Having near and far term trend reports for lake level fluctuation and changes in weather patterns could be used to inform planning and decision-making. Understanding how the natural system has behaved historically and translating climate and hydrological model outputs of how the natural systems are changing can include a companion layer of analysis of social and economic trends. Participants believed that having this type of information would be very helpful to justify decisions and actions. Additionally, perceived benefits of climate change included increased opportunities for renewable energy, and a more pleasant climate for the region. Having a comprehensive social ecological picture of possible climate scenarios could enable communities to more fully recognize and actualize opportunities, as well as mitigate risks.

Concerns about water temperature increase and consequences for ecosystems and duration of ice cover were identified in several of the interviews. Water management issues concerning both quantity and quality ranked high on the issue list, along with the need for ecosystem based management strategies for habitat and natural area preservation. Coastal planning for lake level changes and resilient coastal infrastructure was discussed across nearly all of the interviews. A related concern was the need for decision support resources that identify and characterize anticipated climate impacts, and understanding the implications for development projects. Being able to address issues on a watershed scale (across jurisdictional boundaries) was also a concern. Notably, some impacts may only affect a subset of the population, as some groups are more vulnerable to certain climate impacts. A specific example of this is the impact of water level fluctuation on the yield of wild rice, and the consequences of the loss of a major

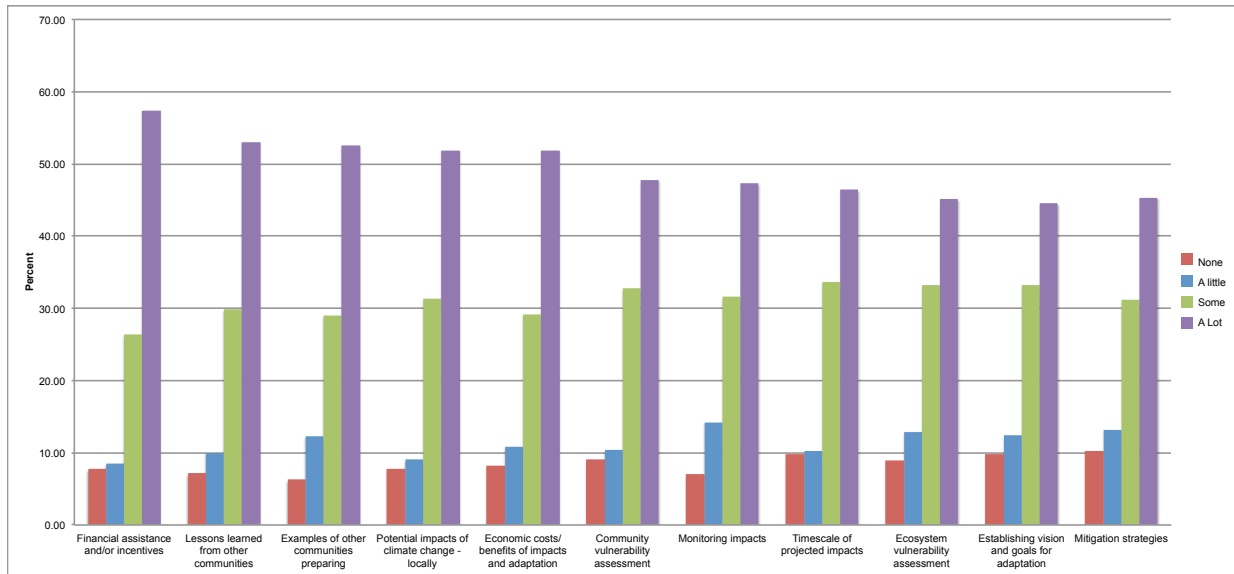


Figure 6. Highest-rated information needs – climate planning.

food source for Tribes and First Nations. Similarly, changes in the aquatic food web may detrimentally impact subsistence fishing, with disparate impact on different groups. Uncertainty about climate impacts and how to communicate impacts to the public was identified as a potential barrier, with the potential to instill or increase mistrust of government officials. Fragmentation in government was considered one of the most significant barriers to develop policies or plan for climate change. Participants felt that education for decision-makers and having high-level advocacy for climate change issues would enable and facilitate effective planning at all scales.

In the survey, Great Lakes benchmark group respondents most frequently said they need “a lot more” information regarding climate change impacts on the economy (31%) among a list of 25 potential impacts. Next was ecosystem restoration, creation, and enhancement, which was selected by 30%, and then ecosystem protection and management (29%) (Figure 7).

6.10 Ecosystem Research and Monitoring (Need 10)

In the focus groups, concerns about public health were often discussed in context of having relevant environmental information about health hazards, such as real-time forecasting of beach conditions and awareness of harmful algal blooms (HABs). Some focus group participants described the need for local monitoring systems, given differences in microclimates and precipitation trends even in small geographical areas. More consistent collection of stream data was mentioned as needed to inform stream models, especially for urban streams.

In the interview data, ecosystem-based management strategies were identified as a priority for habitat, natural areas, and softshore preservation and restoration, as well as wildlife protection and species preservation. Participants emphasized the need for water quality monitoring for beach quality, drinking water quality, and wastewater treatment. Being able to address issues on a watershed scale was also a concern.

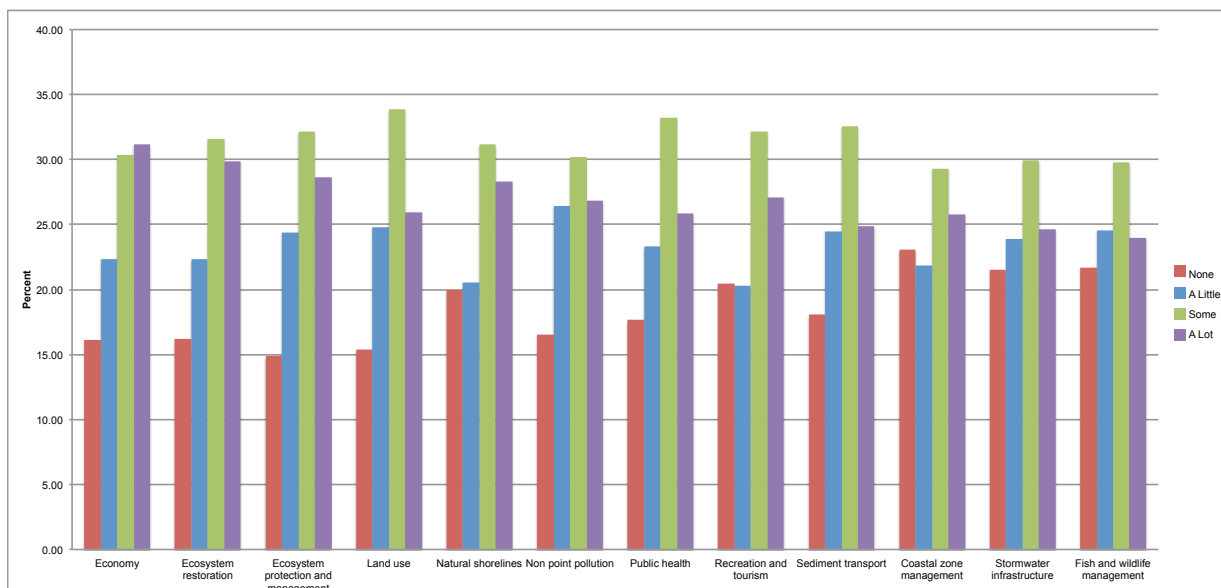


Figure 7. Highest-rated information needs – climate impacts.

Impacts from increasing water temperature and aquatic invasive species on aquatic food webs, as well as changes in duration of ice cover and lake level changes were discussed across nearly all of the interviews. Again, some impacts may only affect a subset of the population, as some groups are more vulnerable to certain climate impacts. As discussed in the previous section, a specific example of this is the impact of water level fluctuation on the yield of wild rice, and the consequences of the loss of a major food source for Tribes and First Nations. Similarly, changes in the aquatic food web may detrimentally impact subsistence fishing, with disparate impact on different groups.

Eighty five percent of Great Lakes benchmark respondents see conserving habitat as a benefit of climate planning. Thirty percent of survey respondents indicated that they need “a lot more information” regarding climate change impacts on ecosystem restoration, creation, and enhancement and 29% regarding ecosystem protection and management.

7. NEEDS FULFILLED BY NOAA AND PARTNERS

Highlighted here are results of the climate adaptation workshops as a primary outcome of this needs assessment.

7.1 PCC Workshops¹⁴

The Ohio Coastal Training Program at Old Woman Creek National Estuarine Research Reserve and the Lake Superior National Estuarine Research Reserve coordinated a regional project to customize *Planning for Climate Change*, a one-day training workshop to address Great Lakes issues and the needs of planners and other professionals working on land use, public health, stormwater, emergency preparedness, and natural resource management issues across the region. This project was developed to address the need for decision-maker trainings (Need 8).

¹⁴ The Planning for Climate Impacts Workshop Evaluation Report is available on the Workshop website at: <http://nerss.noaa.gov/CTPIndex.aspx?ID=663>

7.1.1 Workshop Development

The *Planning for Climate Change* workshop was originally developed by the National Estuarine Research Reserve (NERR) System through its Coastal Training Program with funding from the NOAA Coastal Service Center. The workshop lays a foundation in science and targets actions that can be taken to prepare and adapt to the anticipated impacts of climate change. The course was piloted in Washington State and has been offered in several coastal states.

For this project, Great Lakes region workshops were developed for Cleveland, Ohio; Duluth, Minnesota; and Green Bay, Wisconsin and held in late summer 2011. Staff of the Old Woman Creek and Lake Superior National Estuarine Research Reserves convened three planning teams, one associated with each workshop, which used the results of this assessment in concert with local knowledge of needs and climate resources to customize the NERRS *Planning for Climate Change* workshop for the Great Lakes region. Planning teams identified the target audience for all three workshops as professionals involved in planning and decision-making related to land use, public health, stormwater, emergency preparedness, and natural resource management. The teams also agreed upon a set of learning objectives described below:

- (1) Increase participant understanding of the following:
 - (a) Basic climate science principles
 - (b) Best available local and regional data related to climate projections
 - (c) Potential impacts from climate change
 - (d) Planning processes, resources, and actions that can help communities prepare for and adapt to climate change impacts
 - (e) Potential barriers to climate change adaptation and tools and resources to overcome these barriers
 - (f) Potential benefits of climate change adaptation
- (2) Create opportunities for networking and dialogue related to potential climate change adaptation strategies and regional examples of climate planning and adaptation

Planning teams developed regionally tailored messages and products to market the course. The course title *Planning for Climate Change* was adjusted to *Planning for Climate Impacts* and a phrase localizing the title was added:

- *Planning for Climate Impacts in Northern Ohio*
- *Planning for Climate Impacts in the Western Lake Superior Region*
- *Planning for Climate Impacts in Northeast Wisconsin Communities*

The tag lines ‘Safeguarding our economy, environment, and quality of life’ and ‘capacity building workshop’ were also utilized. The Ohio Department of Natural Resources Office of Coastal Management developed a save the date flyer in consultation with workshop planning teams that featured graphics of the Lake Superior, Michigan, and Erie coasts; images of the lakes and recreational uses; and a National Climate Assessment report graphic illustrating sectors affected by climate change. Sponsors and collaborating partners were included on the flyer.

Over 240 planners, stormwater professionals, natural resource managers, public health professionals, emergency preparedness staff, and private industry representatives participated in the training¹⁵. Most participants were affiliated with universities (19%), state government (18%), non-profit organizations (15%), or local government (13%). The remaining participants were affiliated with county government, private industry, federal government agencies, regional government agencies, and tribal governments. Nine members of the American Institute of Certified Planners earned six certification maintenance credits for participating in the Cleveland workshop.

Each workshop began with an overview of climate change science and regional impacts. The existence of downscaled climate information applicable to Western Lake Superior and Northeast Wisconsin allowed for further localization of the content for these two workshops. All three trainings also covered fundamental concepts in climate planning, provided a review of available tools and resources to aid in climate planning, and included an interactive activity through which participants identified and discussed potential adaptation strategies for vulnerabilities in their communities. Depending on local needs and interests, regional case studies of climate planning, the economics of adaptation, and public health impacts were also covered in one or more workshops.

In addition to the Old Woman Creek and Lake Superior National Estuarine Research Reserves, workshop sponsors included the Ohio Department of Natural Resources Division of Wildlife, the University of Wisconsin Extension, University of Wisconsin Environmental Resources Center, NOAA Coastal Services Center, Green City Blue Lake Institute at the Cleveland Museum of Natural History, Ohio Lake Erie Commission, Ohio Coastal Management Program, Great Lakes Sea Grant Network, United States Environmental Protection Agency, and the Cofrin Center for Biodiversity at the University of Wisconsin Green Bay. Workshops were funded by the Great Lakes Restoration Initiative and Old Woman Creek National Estuarine Research Reserve.

Collaborating partners¹⁶ that provided input on training design through local planning teams included Great Lakes Sea Grant and Coastal Zone Management Programs and a wide array of other local, state, and federal agencies such as EPA, U.S. Fish and Wildlife Service, tribal governments, universities, community leaders, ICLEI Local Governments for Sustainability, local chapters of the American Planners Association, The Nature Conservancy, and other conservation NGOs.

7.1.2 Evaluation Surveys and Outcomes

*“There will be no more hesitation on my part in saying that the climate has and is changing. The science based historical data presented for Wisconsin and Minnesota on changes in temperatures, dew points, storms, rainfall levels and stormwater runoff and the consequences and impacts on health, natural resources, the economy, water levels and temperature is valuable and important proof that climate change is real. Now, I can speak to this subject with or without addressing the man-made contribution to climate change. **The workshop was the first opportunity that I have had to consider adaptation as a proactive activity.** The research, analysis and presentation of adaptation topics, strategies and the processes to adapt to climate change presented at the workshop are all new information for me.”*
– Training workshop participant (emphasis added)

¹⁵ Agendas and workshop presentations are posted at: <http://nerrs.noaa.gov/CTPIndex.aspx?ID=663>

¹⁶ A complete list of collaborating partners can be found at the end of this document.

The workshop was the first opportunity that I have had to consider adaptation as a proactive activity. Sixty-four percent of participants completed an online survey immediately following the workshop. Thirty-nine percent of respondents strongly agreed and 48% percent agreed that participating in this event was a good use of their time. Participants reported large knowledge increases related to climate adaptation. Ninety-one percent of evaluation respondents said the workshop increased their knowledge of climate adaptation “some,” “a lot,” or “a great deal.” Several participants said that they had little prior knowledge of adaptation planning approaches or strategies and some indicated that they knew little about the science. Others indicated that they came to the workshop with some understanding but that the experience took their knowledge to the next level. Seventy-two percent of respondents indicated they learned something new that they will apply in their work or future decisions. Participants in the Green Bay and Duluth workshops reported knowledge gains relative to all workshop objectives in post versus pre workshop surveys.

Most useful aspects of training

Several participants indicated that the sharing of climate science, information regarding regional impacts, adaptation basics, and local adaptation case studies were the most useful aspects of the workshop. Others found the roundtable discussions and the vulnerability assessment activity to be the most valuable aspect of the training. For the Cleveland workshop, several participants noted that sessions covering the economics of adaptation and public health impacts of climate change were most useful.

Opportunities for improvement

Participants in all three workshops identified similar opportunities to improve the workshop. Several suggest that the workshop would be improved by incorporating more case studies, reducing lecture time, and more opportunities for interactive, engaged learning. Some wanted more details regarding adaptation strategies and examples, including hands on examples and demonstration of tools. In Duluth and Wisconsin there was a desire for more mapping information. Some participants thought the training should be longer and several provided suggestions regarding improvements to presentation style and technical logistics. Quotes from respondents related to potential improvements included the following:

- *Build a model community and have participants identify and implement changes. It's easy to “make changes” but there are trade offs. I think adding this piece to the discussion will begin to identify additional topics.*
- *Topics were great but need to be framed in a format where participants play an active role and are engaged in learning and in putting what they learn into action.*
- *Have breakout sessions with in-depth info about how to do adaptation related to impacts like increased stormwater, flooding.*

Respondents cited a number of obstacles to applying what they learned at the conference including lack of public, political, and agency support; low levels of climate literacy among the general public and key decision-makers; perception that climate change will impact others far into the future and in other places; fiscal constraints; and scientific uncertainty regarding impacts.

Participants indicated that additional training could assist them in overcoming obstacles, particularly if the training focuses on the science related to regional impacts, specific adaptation options and local adaptation case studies. Education of elected officials was mentioned by several respondents as an

important need as was economic analyses of impacts and adaptation options. Quotes from respondents related to additional training or assistance that would help address obstacles included the following:

- o “Continuing to provide examples of how climate change is specifically impacting the natural resources, agriculture, infrastructure and the economy. Hold regular forums on local case studies to help build a bridge for planners, engineers, administrators and legislators on how the environment is changing and what needs to be done.”
- o “Workshops like these, events or outreach/information programs that can effectively take the climate change concept and translate it to formats that are more readily understood and accepted, like public health and safety, flooding, and stormwater concerns.”
- o “Intensive facilitated discussion that brings regional groups to consensus on adaptation strategies that they can jointly work on; as well as individual community actions that they can take right away.”
- o “Promoting climate adaptation as best practices and having an economic pay-off - in the way the Brookings Institution promoted Great Lakes restoration - help us message and sell this to decision makers. I imagine there is an important role for assistance for municipalities to help them address building climate change resilience into limited budgets and show city leaders why they must address it.”

Future training needs

There was a great deal of consistency across the three workshops in terms of what participants identified as future training needs. Future needs include:

- Specific practices, policies, codes, and ordinances that address adaptation
- More examples of adaptation programs
- Economic costs of climate change and cost benefit analysis of adaptation options
- Local examples of impacts including phenology change, stormwater impacts, mapping of habitat impacts, emergency preparedness implications, invasive species, water withdrawals (Great Lakes Compact), and ground water supplies
- Education of elected officials and more specific target audiences
- Collaboration
- Funding
- Legislative work
- Climate science
- Accessible data and tools
- Messaging

7.1.3 Vulnerabilities and Adaptation Options Identified in Workshops

During an interactive exercise, participants identified key vulnerabilities to climate change, discussed potential adaptation strategies, brainstormed key stakeholders, action time frames, next steps that can be taken locally, and barriers to implementation. Across all three workshops and particularly in Cleveland, participants identified the impacts of increased runoff on stormwater infrastructure as a key vulnerability. Robust discussion on the barriers to and benefits of adapting to increased stormwater runoff revealed awareness of vulnerabilities across a spectrum of sectors, and workshop participants were aware of appropriate response strategies, all of which were consistent with findings from the needs assessment.

Changes in species composition resulting from range changes, invasive species impacts, loss of vulnerable species, and loss of habitat were identified as key vulnerabilities for the region's natural resources. Other key vulnerabilities discussed included heat related stress, impacts on drinking water quality, loss of fisheries and recreational opportunities, loss of tourism revenue, and impacts on shipping. Potential strategies that participants identified to reduce impacts on infrastructure, ecosystems, and communities included (but not limited to): strengthening local policy and planning regulations, separating combined sewer systems and employing green infrastructure design, restoring and protecting wetlands, and educating engineers, infrastructure managers, and public on the value of storage and infiltration of water rather than conveyance.

Workshop participants identified several barriers to and benefits of adaptation actions, many of which were consistent with those identified through the needs assessment. Barriers included lack of funding, guidance, political will, cooperation, and knowledge of vulnerabilities and adaptation options. Benefits included increased quality of life, improved water quality, reduced flooding and property damage, improved property values, lower incidence of waterborne disease, and lower energy costs. Full discussion of the results from the vulnerability exercise are available in the workshop evaluation report.¹⁷

7.1.4 Outcomes: Information Sharing, Application to Decision-Making and Management

In June 2012, 76 participants who had agreed to be contacted after the workshops were surveyed to assess whether and how they have applied information gained through the training. Of the 28 who responded, almost all (93%) have shared information from the workshop with others such as professional colleagues and organizational partners. Eighty-six percent said they are using the information in their current work or decision-making. Some indicated that they have integrated the information into regional adaptation plans and multi-hazard mitigation planning processes to address flooding problems, others have used it on websites, to write grant proposals, provide technical guidance for development projects, or to develop education programs for community leaders, citizens, and students.

Seventy-one percent said they have encountered obstacles to applying the information including lack of agency acceptance that climate change is occurring, limited staff time and funding, need for better information about adaptation options, and lack of political and public acceptance. Forty-three percent think that follow up technical assistance with selecting adaptation strategies, communicating with stakeholders, conducting vulnerability assessment or with using visualization or other decision support tools would help them to overcome these obstacles.

When asked what they think is the most critical vulnerability to climate change in the community or ecosystem they plan for or manage, several cited ecosystem and infrastructure vulnerabilities to more frequent intense storms including flooding, erosion, nonpoint source pollution, and harmful algal blooms. Others saw migration of pests and species loss, impacts to local economies, lack of funding, absence of state policies that incentivize adaptation and mitigation, low public awareness and support, and low understanding of potential health impacts as key vulnerabilities.

Several respondents said they have changed their planning or management in response to knowledge gained at the workshops. Some are considering climate change impacts when developing natural resource management plans, and others have integrated the information into education programs and watershed

¹⁷ Available at: <http://nerrs.noaa.gov/CTPIndex.aspx?ID=663>

action planning. One community implemented a sustainable zoning code that includes adaptation strategies, and another is using the information to review proposed local zoning policies.

7.2 NOAA and Partners

A major outcome for this needs assessment has been to inform the development of a regional climate science and service plan. While NOAA has developed several programs to meet information and training needs, this does not preclude others outside of NOAA addressing these needs, where they are uniquely suited to do so. Many agencies throughout the region are engaged in climate planning, and the challenge is to ensure that climate work is effectively coordinated so that efforts are complementary and building on one another.

Issue areas that present opportunities for needs fulfillment include, but are not limited to, the following: considering natural habitat complexity as a key feature to enhance resilience; adapting forest management to assist species migration and redistribution, establishing new protected forests, and allowing natural regeneration after disturbances. Improving tracking and monitoring of invasive species and ecosystem conditions in order to evaluate existing prevention measures and future threats in the context of climate change, as well as utilizing parks as long-term integrated monitoring sites for climate change. Identify representative Great Lakes ecosystem locations to serve as Sentinel Sites for the impacts of climate change, such as the Lake Superior and Old Woman Creek National Estuarine Research Reserves. Finally, having financial support, political guidance, and resource leverage for local climate adaptation efforts is an ongoing need in all Great Lakes communities, and in various capacities.

8. RECOMMENDATIONS AND NEXT STEPS

Throughout this assessment, the need for collaborative research and learning has been explored from multiple perspectives. The National Research Council (2009) recommends that decision support services should engage an interdisciplinary structure (p. 67), as well as using an analytic and iterative approach for decision-making (p. 78-84). Furthermore, focusing on user needs and skills is an essential component for developing effective climate services (National Research Council, 2010:168-169). Given these considerations, it is possible that requiring engagement of end-users in collaborative research, learning, and implementation projects in requests for proposals (RFPs) could expedite implementation of this approach across the region. Additionally, the wealth of information regarding regional needs gathered in this assessment, and other assessments in recent years, could be synthesized and communicated to a broader audience through forums and symposiums and mapped to available resources that address these needs. The survey data revealed this type of delivery mechanism to be among the most trusted sources for information. Other recommendations include:

- I. Develop and expand educational tools and resources to increase understanding of climate impact scenarios that include modeling output and anticipated trends for natural, social, and economic systems. Having a comprehensive social and ecological picture of possible climate scenarios will enable the public and policy-makers to more fully recognize, anticipate, and actualize opportunities and mitigate hazards. Determine regionally specific ‘no-regrets’ policy options for each of the Great Lakes, and as a collective.
- II. Increase capacity for local and regional monitoring of the Great Lakes, as well as the coastal watersheds. Develop public-private and citizen science partnerships to collect and analyze

data. Further develop and strengthen regionally coordinated efforts to maintain monitoring systems. Educate policy-makers on the need and justification for funding the implementation and maintenance of large lake monitoring systems.

- III. Develop partnerships and regionally coordinated efforts to leverage funding for large-scale projects. Strengthen communication with policy-makers and include specific cost-benefit analyses for anticipated improvements.
- IV. Pursue research of the social and economic impacts from climate change currently and longitudinally. Perform analyses that couple social and ecological systems, and engage high school and college students in the research.
- V. Generate near and far term trend reports for lake level fluctuation and changes in weather patterns to inform planning for fishing and tourism seasons. Include social and economic trends analysis in climate change research and modeling to illustrate how natural system changes affect decision-making for local communities and tourists.
- VI. Conduct assessments that identify additional gaps and needs for particular sectors, demographic and professional groups, and geographies.
- VII. Conduct and fund research that quantifies the current and future benefits of adaptation for environmental quality and public health to help support adaptation actions.
- VIII. Develop training in use of appropriate social science methods and application for climate change adaptation.
- IX. Develop leadership training and climate literacy programs that engage working professionals, as well as high school and college students.
- X. Develop climate services that engage end-users and incorporate the wealth of knowledge and local expertise across the region. Engage end-users in collaborative research whenever possible. Require this approach in requests for proposals to expedite implementation across the region.
- XI. Develop effective communication between agencies and the public. Develop and refine contextualization regarding uncertainty and ongoing investment to improve models and forecasts.
- XII. Continue and expand delivery of climate adaptation training at the community level throughout the Great Lakes. Build capacity, funding mechanisms, and train-the-trainer support for delivery of local training within NOAA and more broadly in the region.
- XIII. Host symposiums to synthesize and communicate findings from this study, as well as other assessments that have been conducted in recent years. This type of forum could be held annually, to strengthen awareness and understanding across the region.

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